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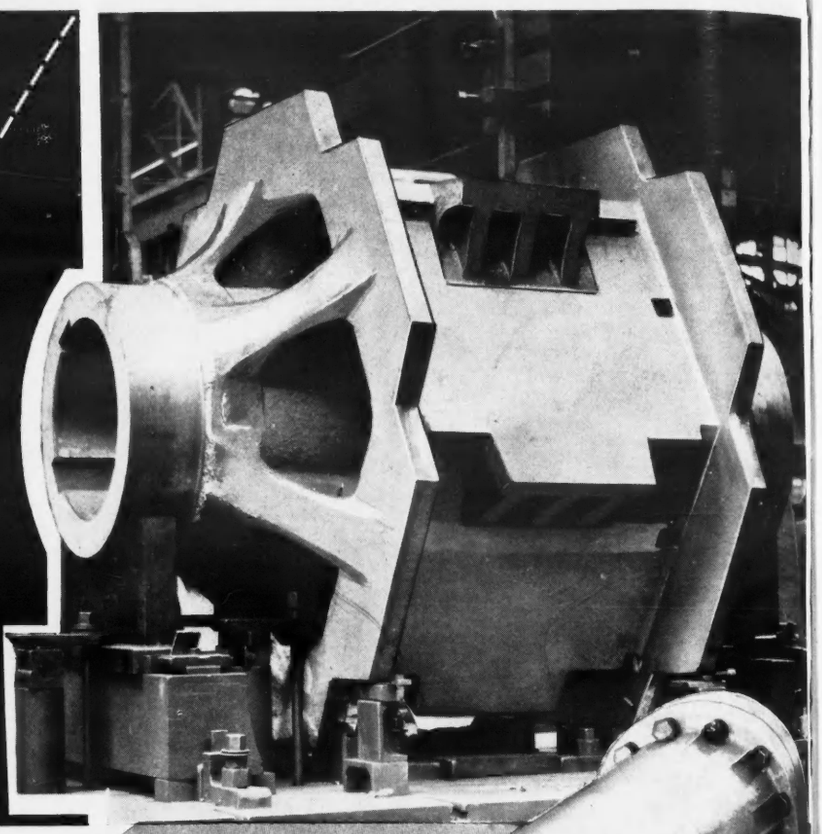

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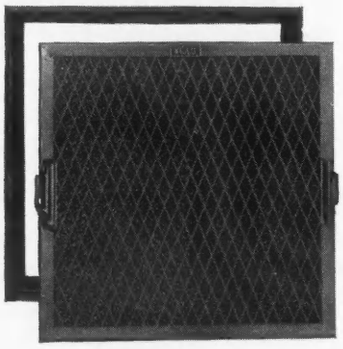

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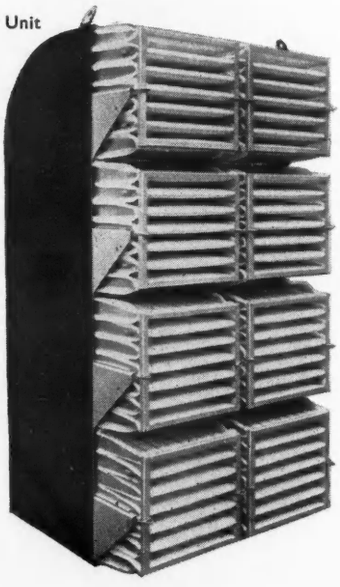

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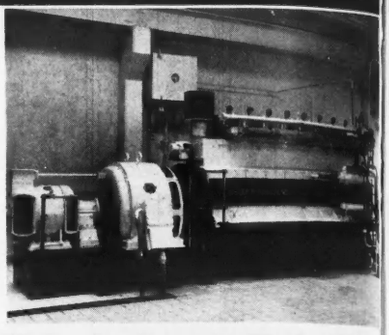

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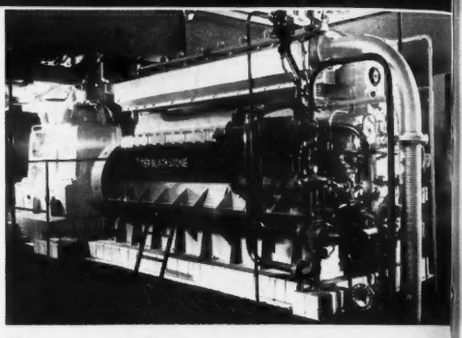

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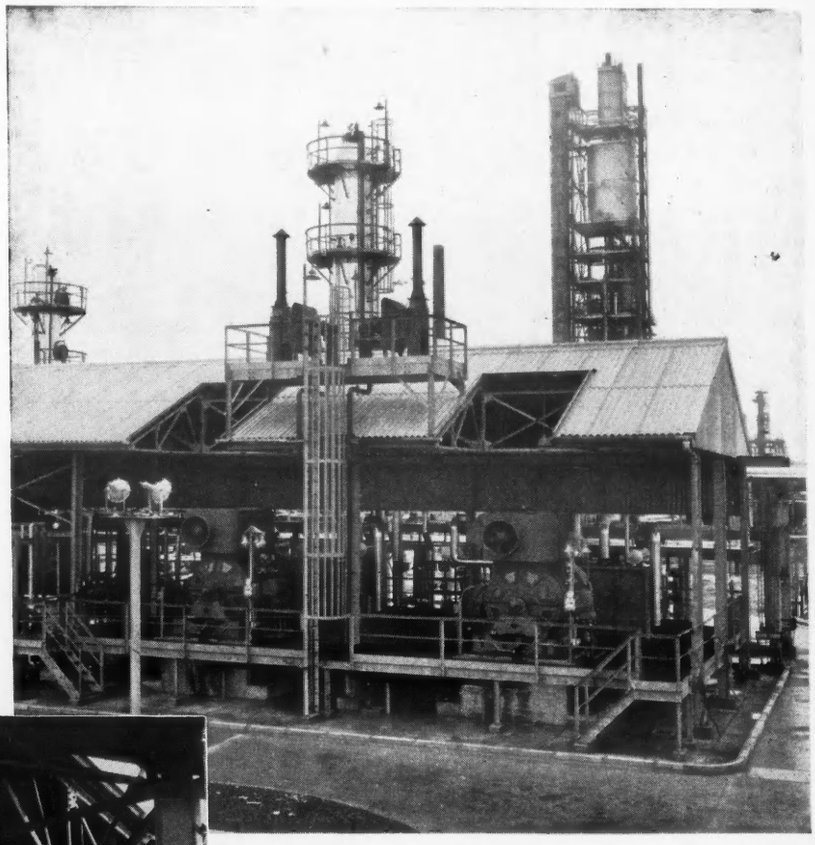

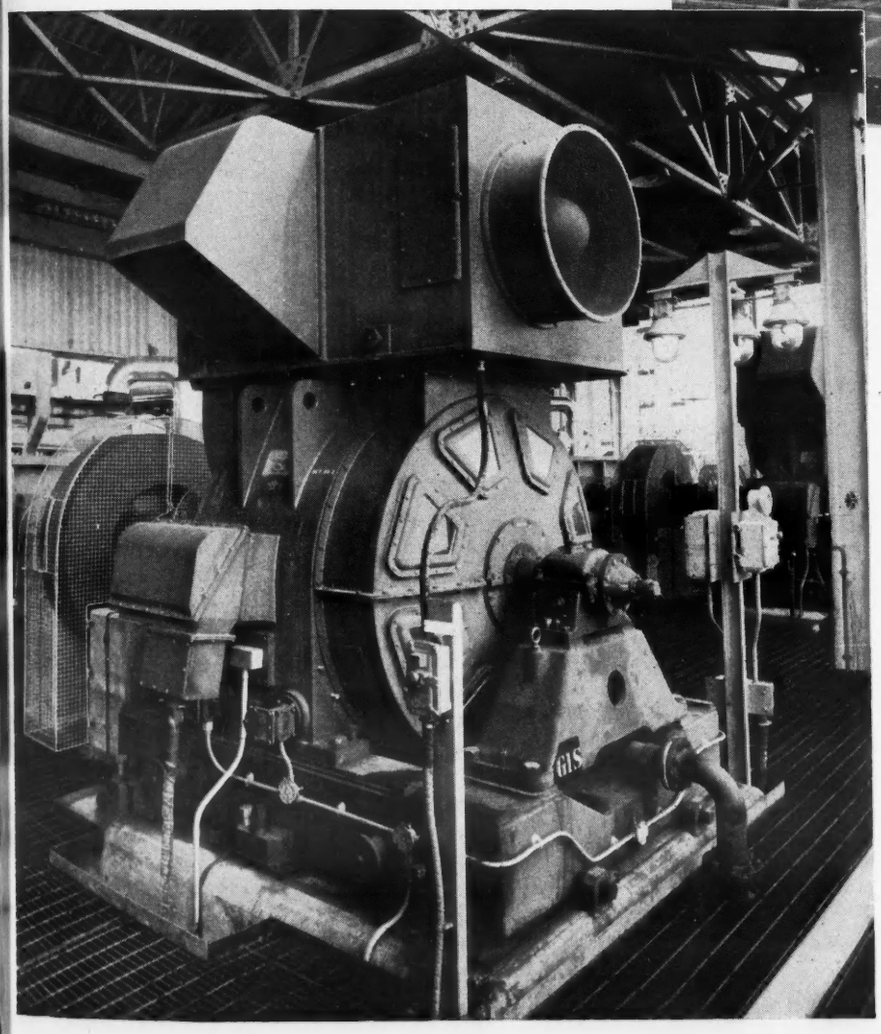

Two 350/120 h.p. 585/200 r.p.m. N-S variable-speed a.c. motors driving gas compressors at Coryton Oil Refinery. Closed-air-circuit type, pressurized from a source of filtered air. (Photographs reproduced by courtesy of the Mobil Oil Company Ltd.)

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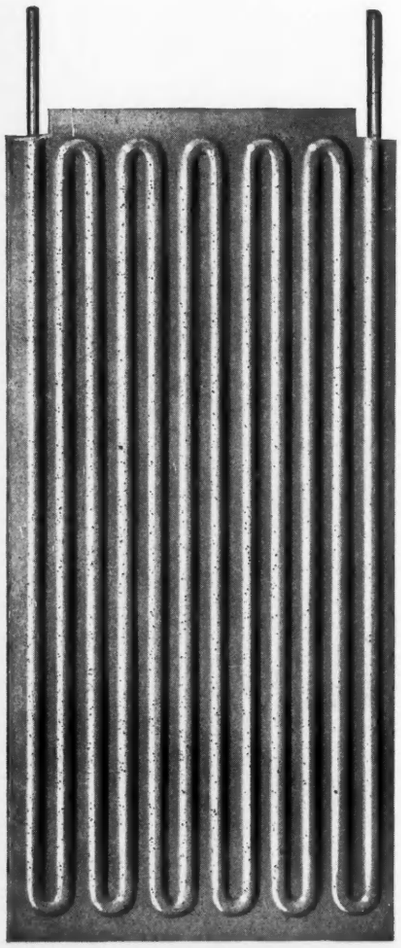

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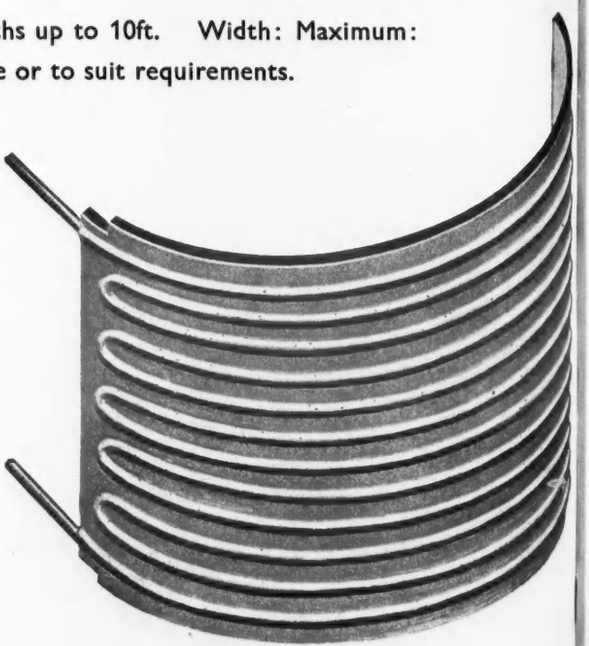

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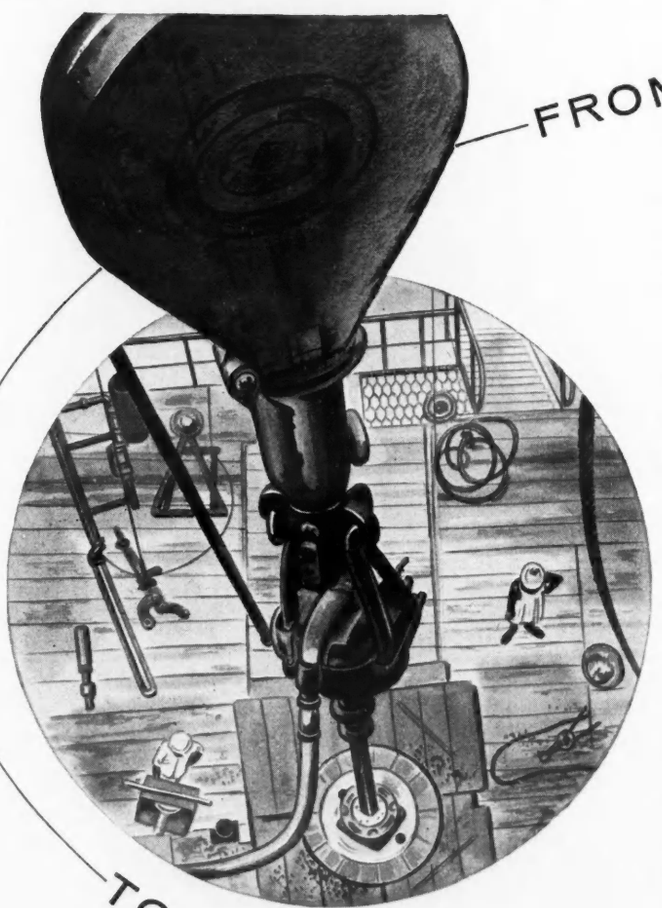

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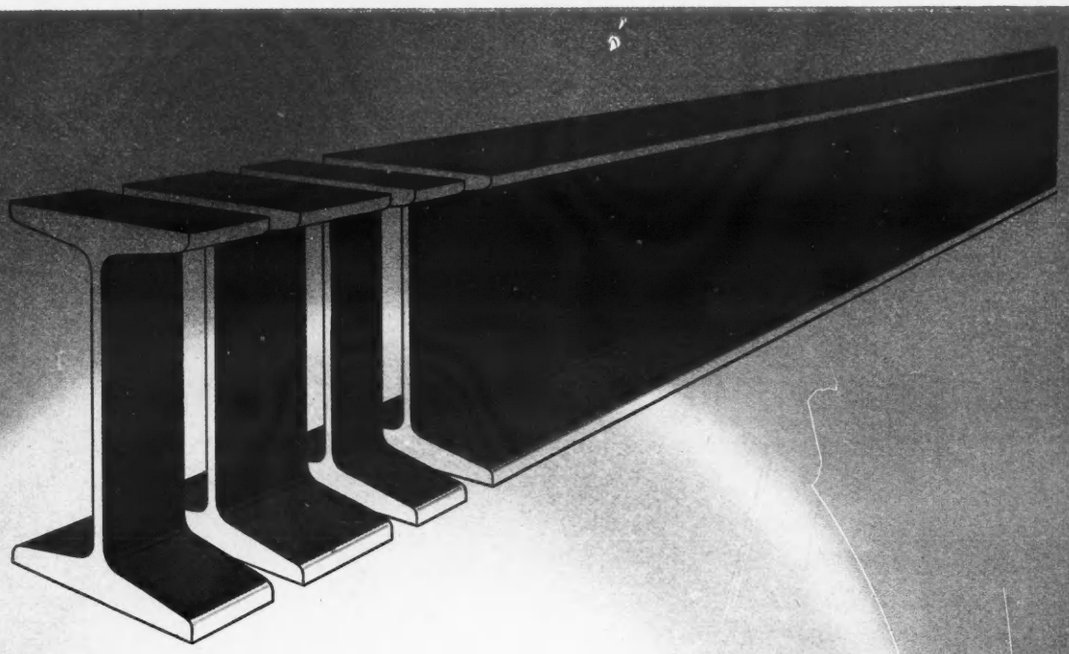

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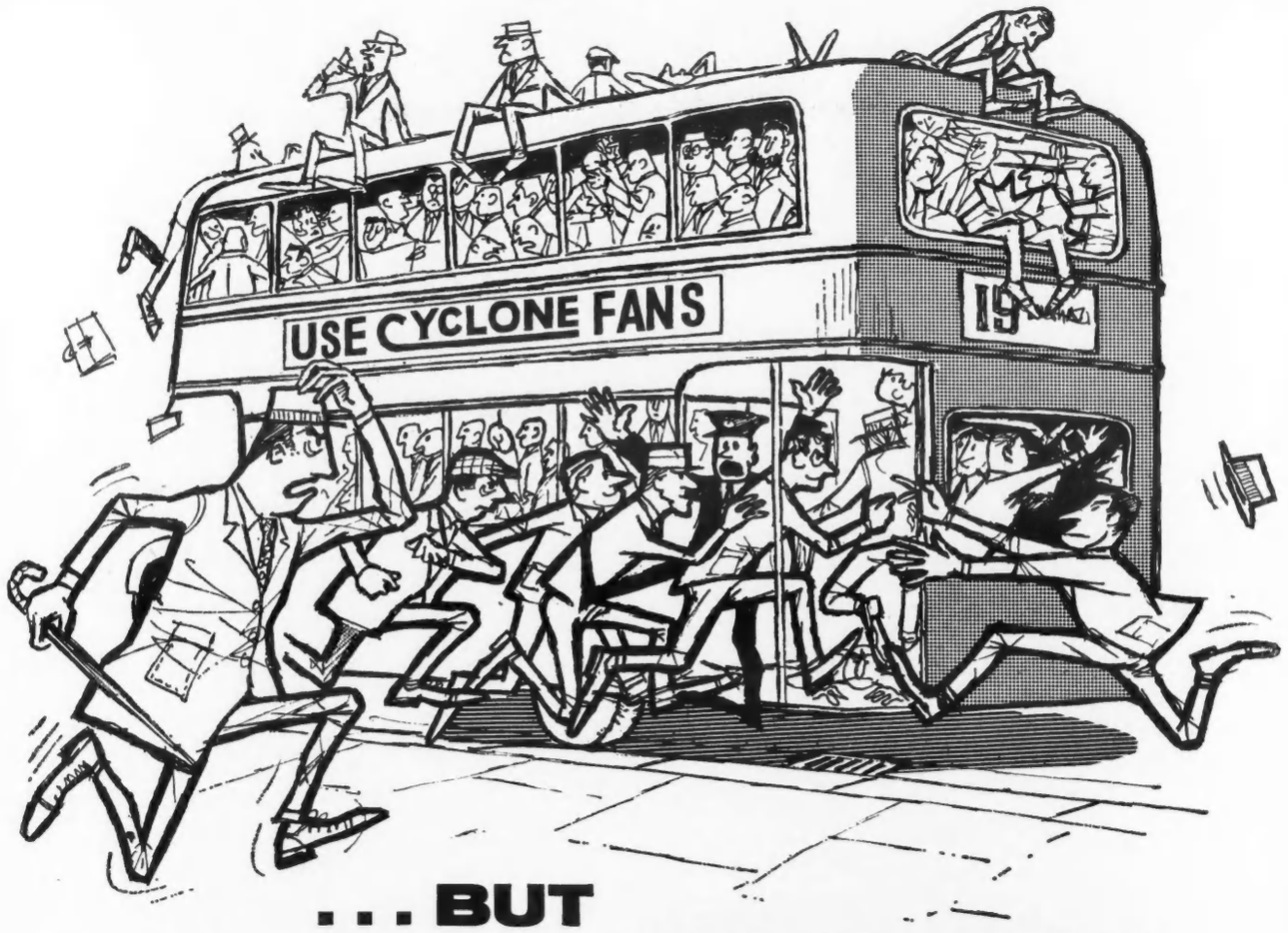

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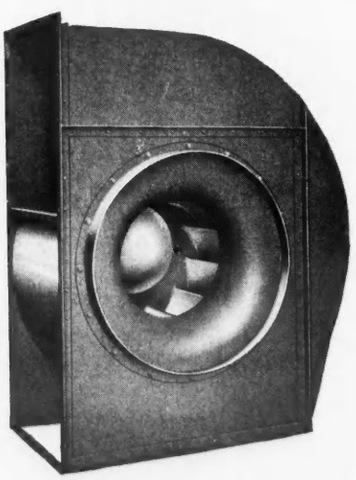

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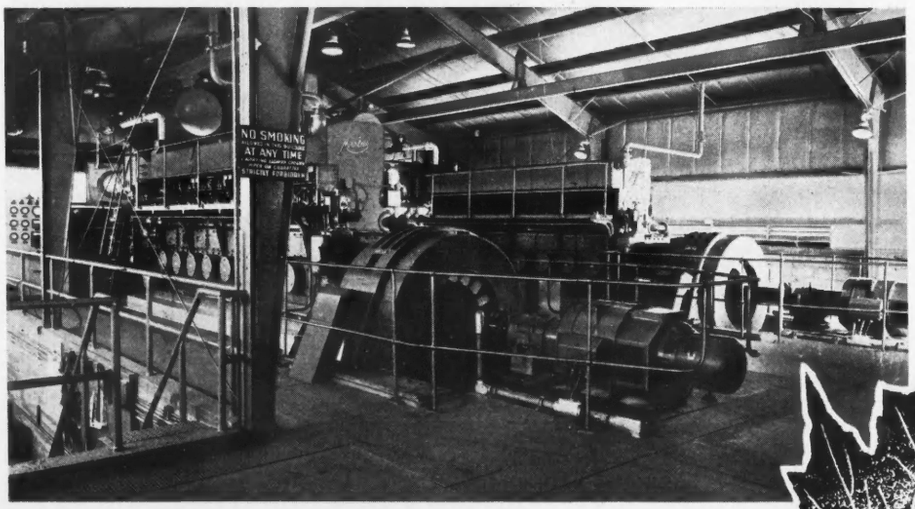

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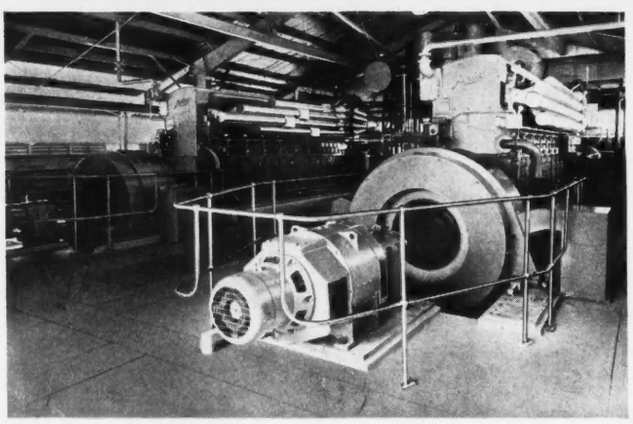

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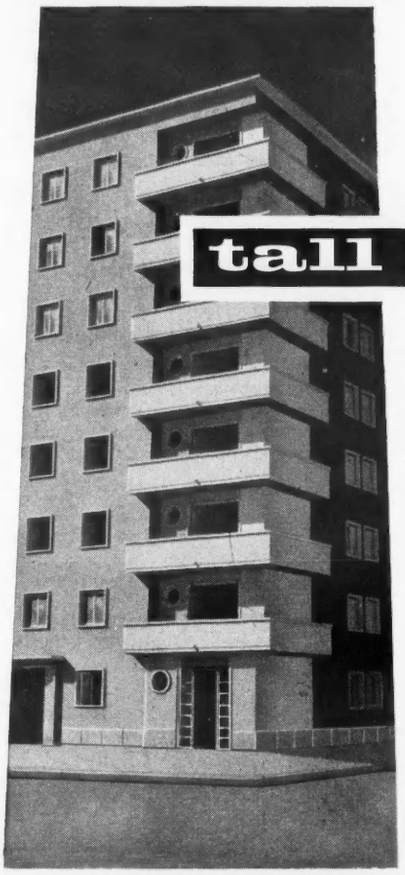

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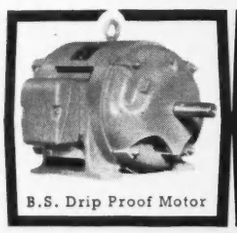
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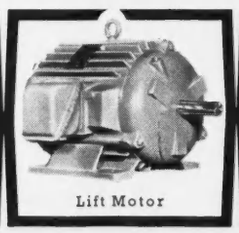
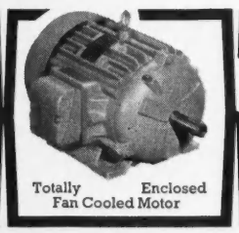

Lift Motor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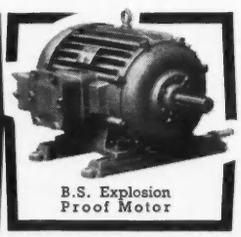
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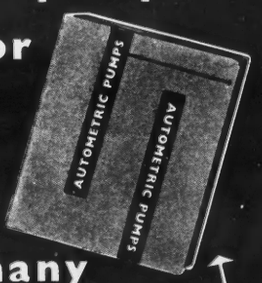

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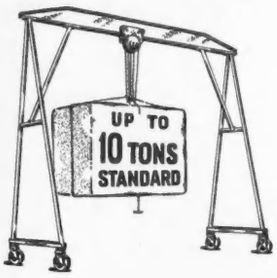

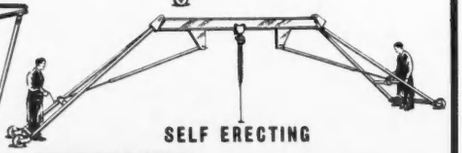

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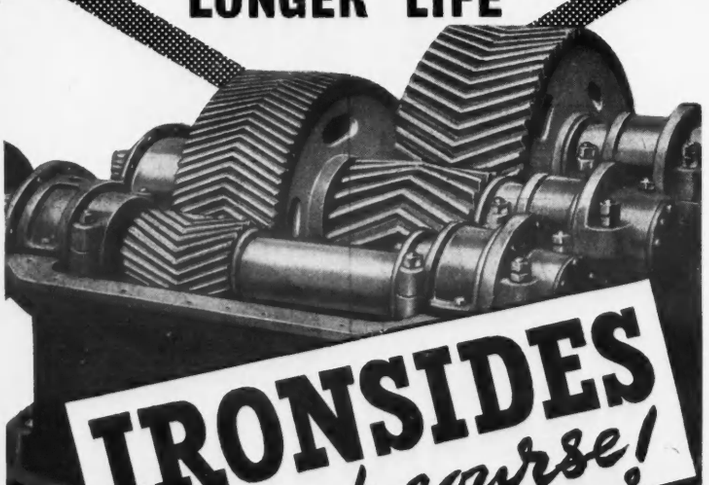

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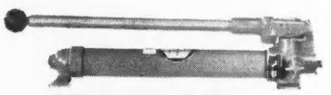

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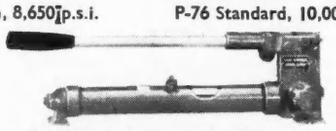

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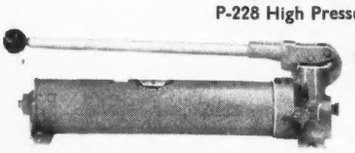

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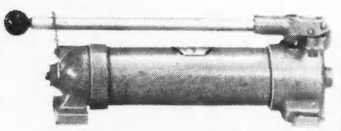

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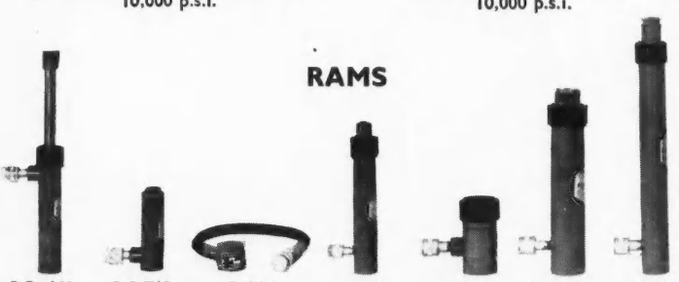

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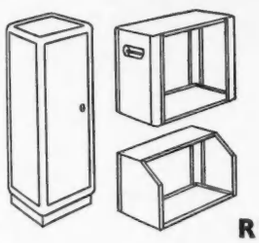

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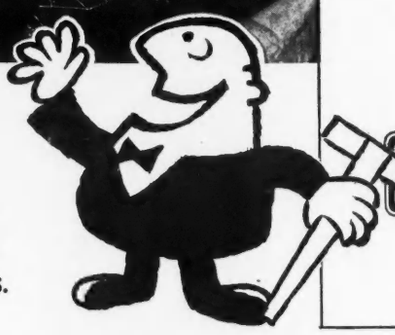

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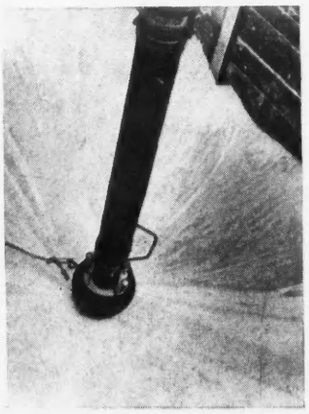

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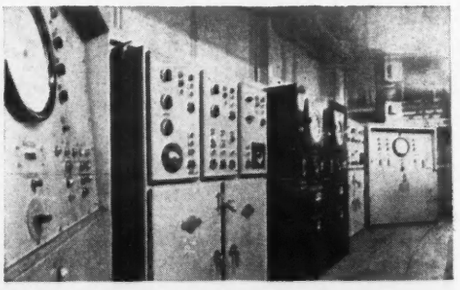

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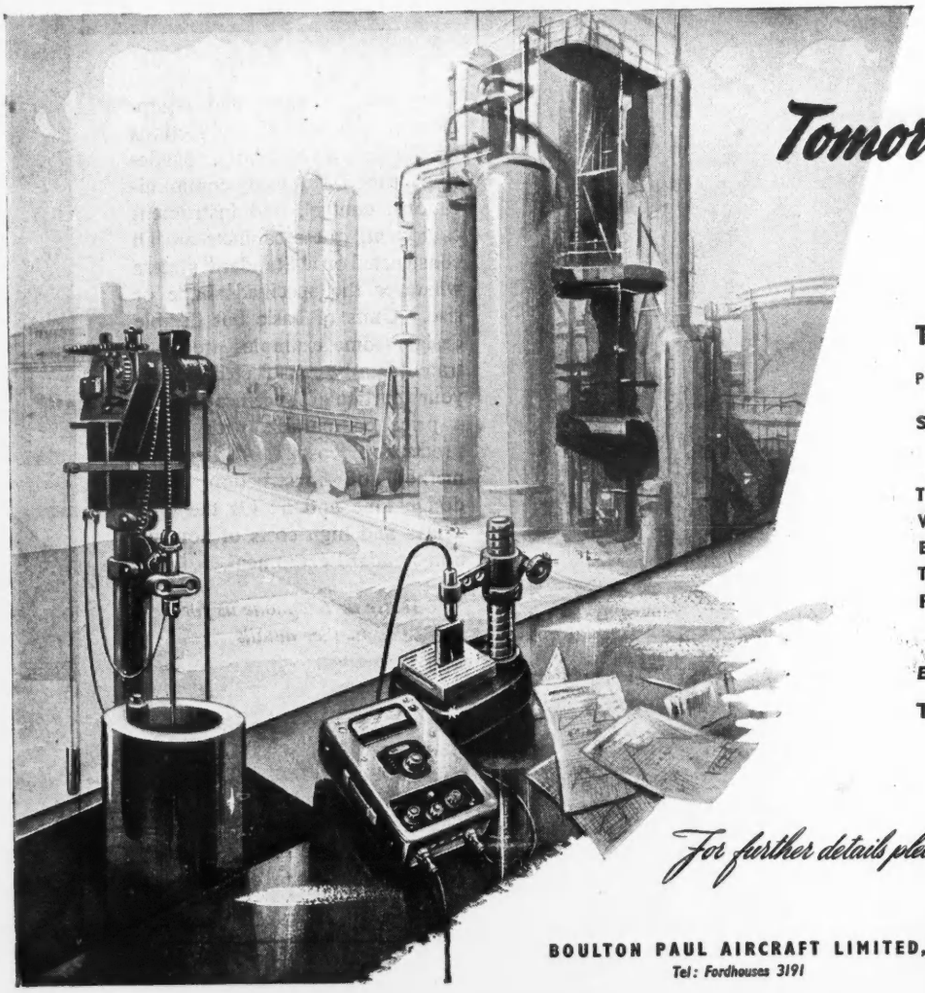

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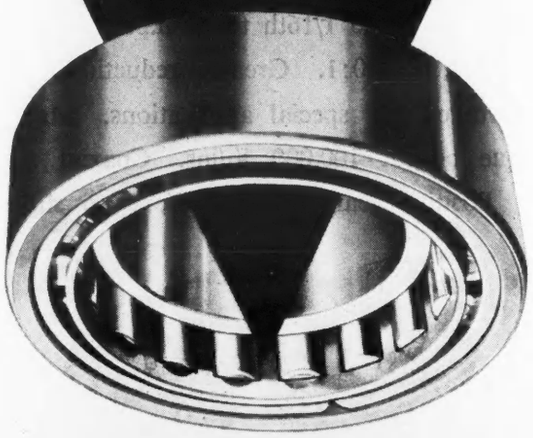

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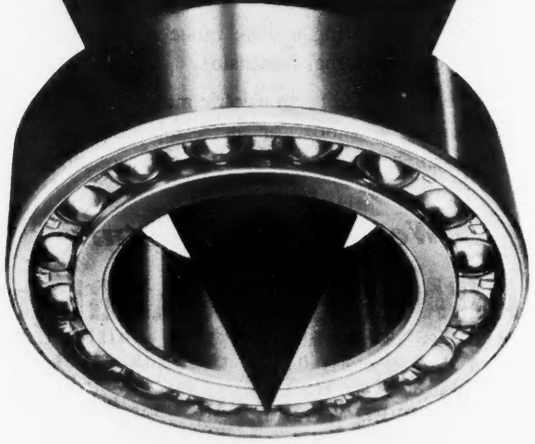

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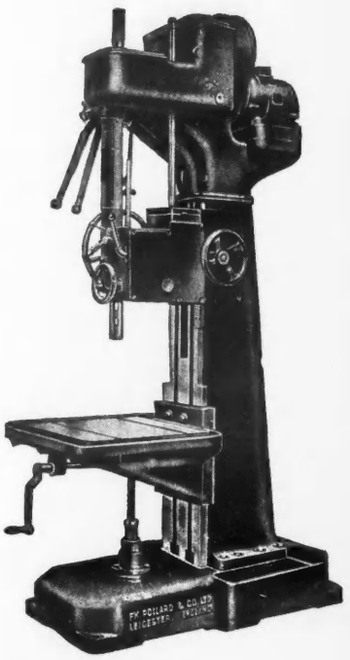

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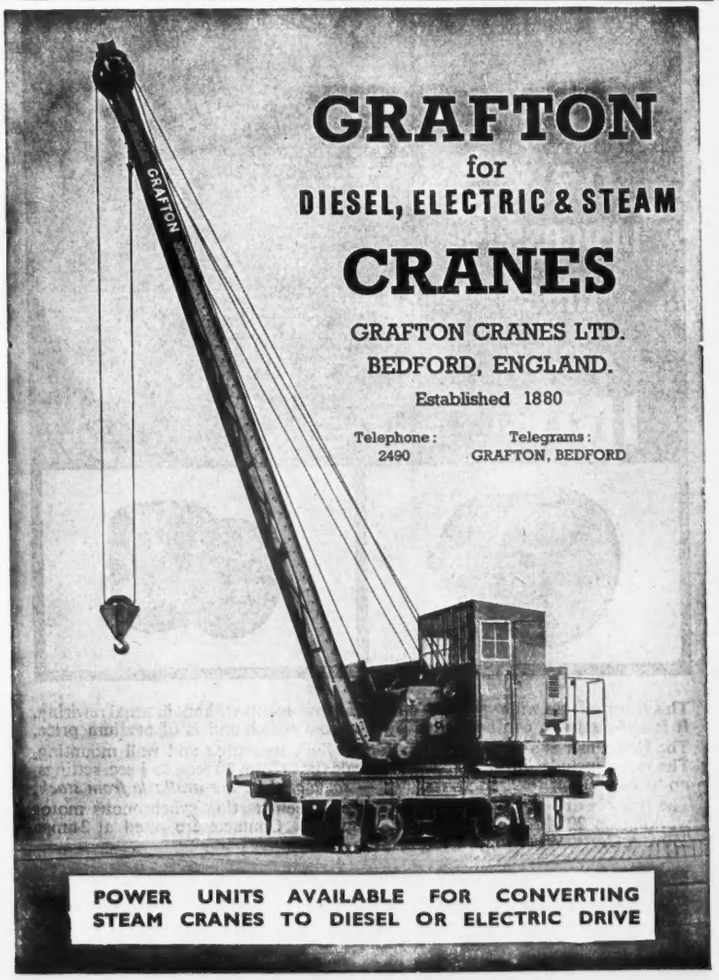

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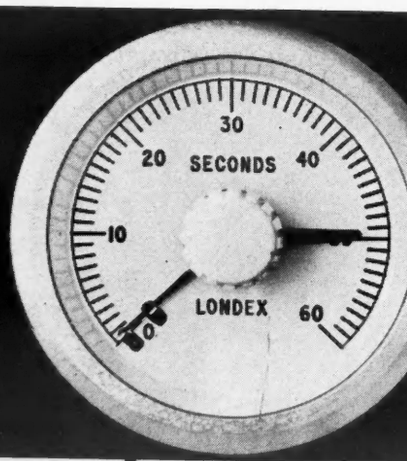

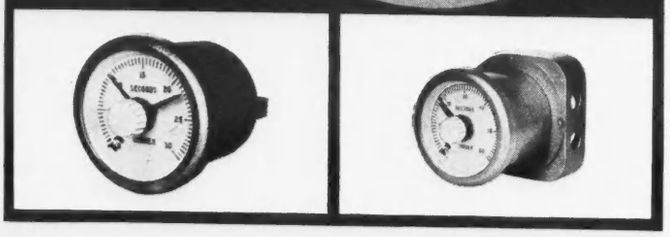

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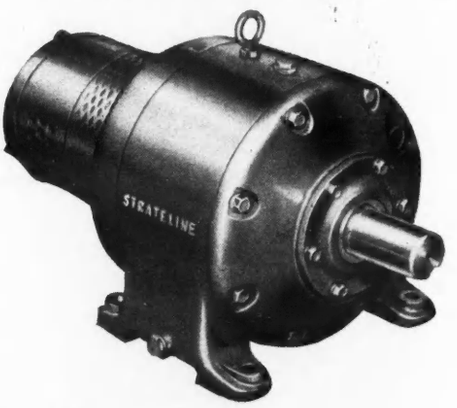

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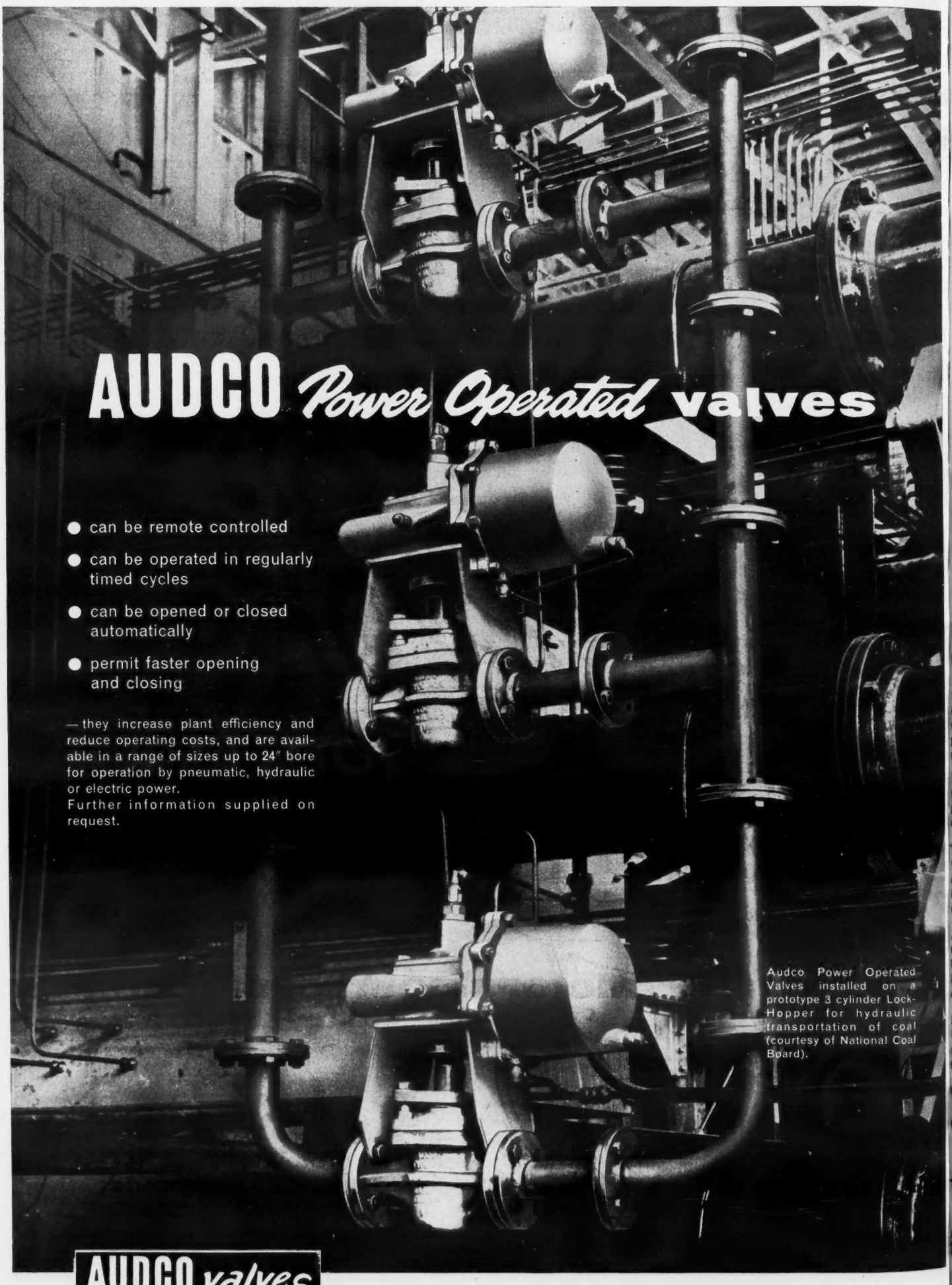

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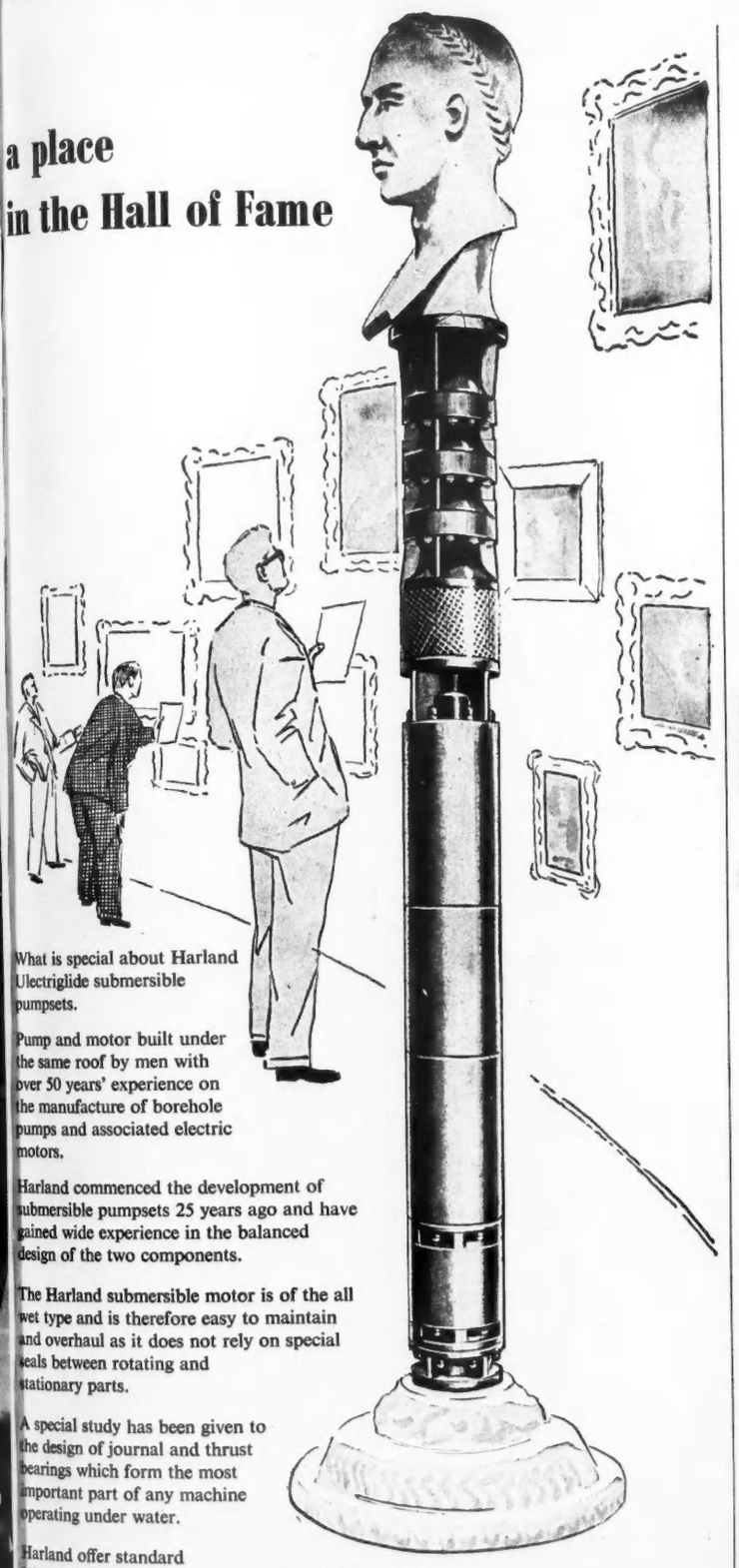

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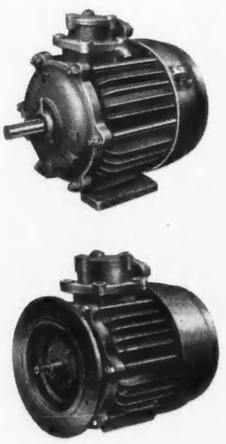

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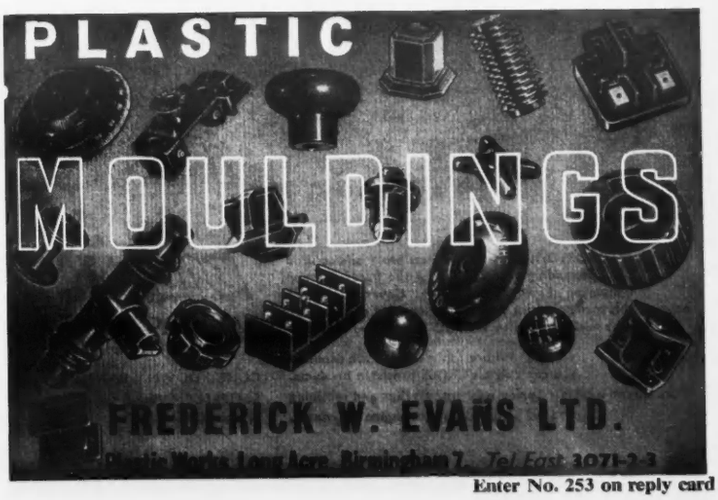

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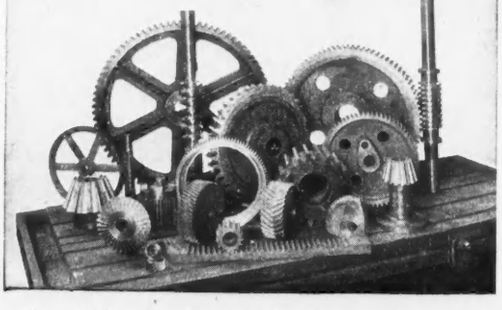

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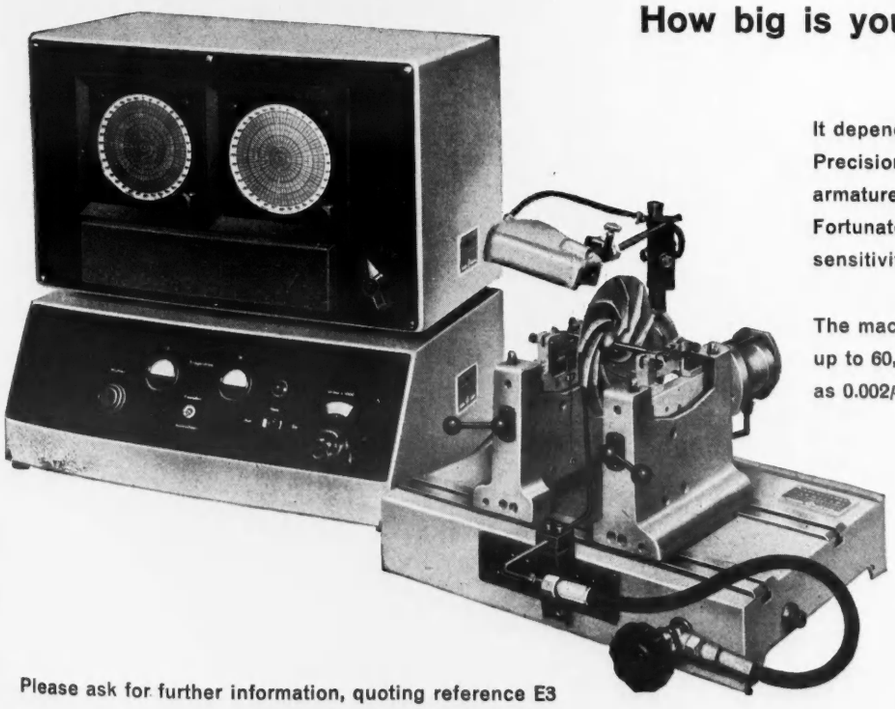

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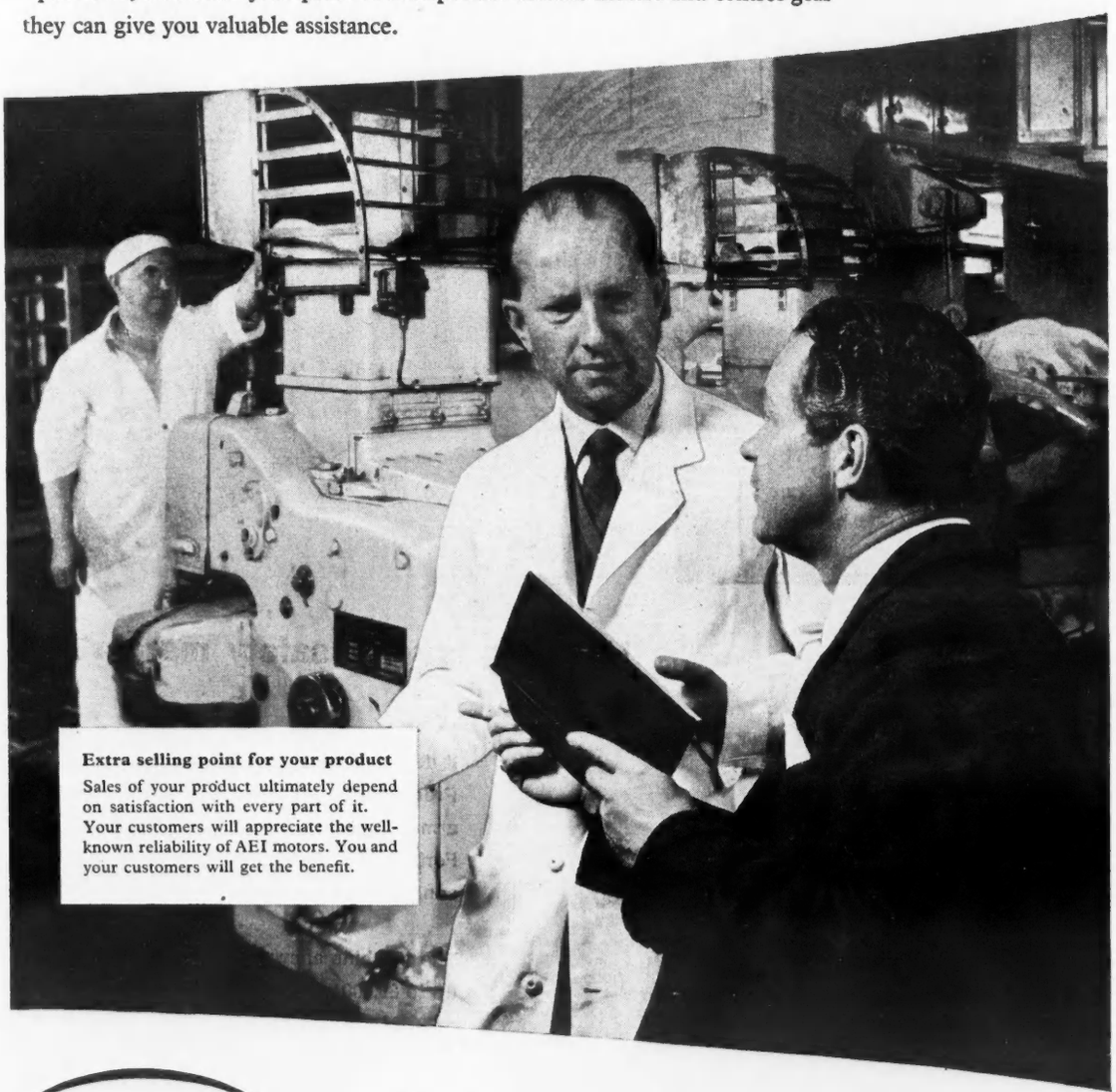

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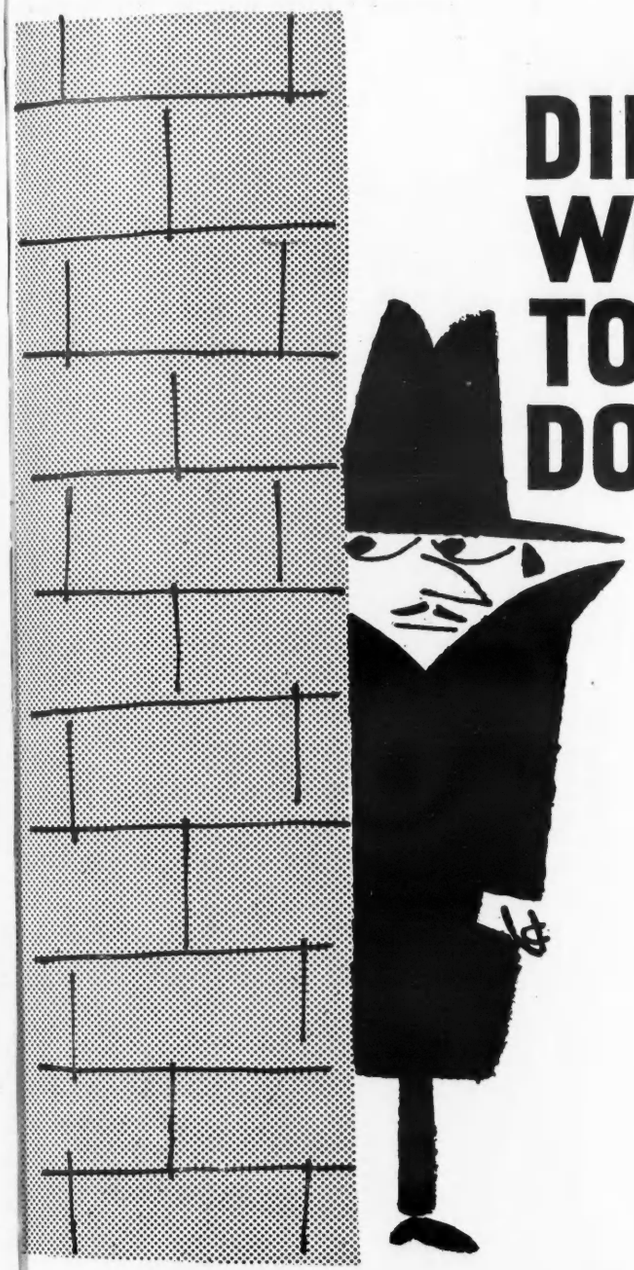

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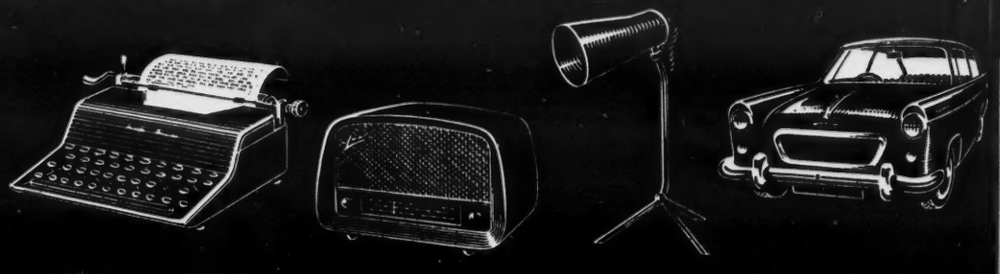

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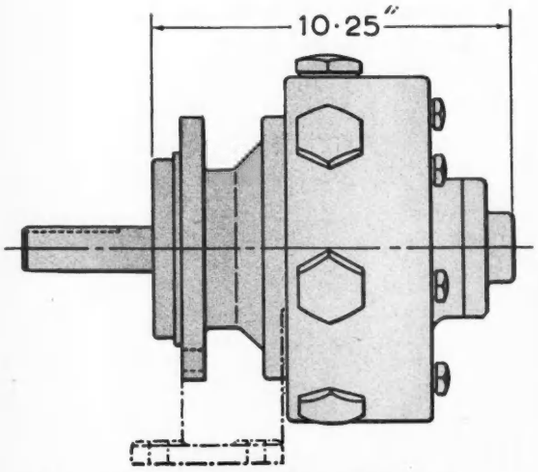

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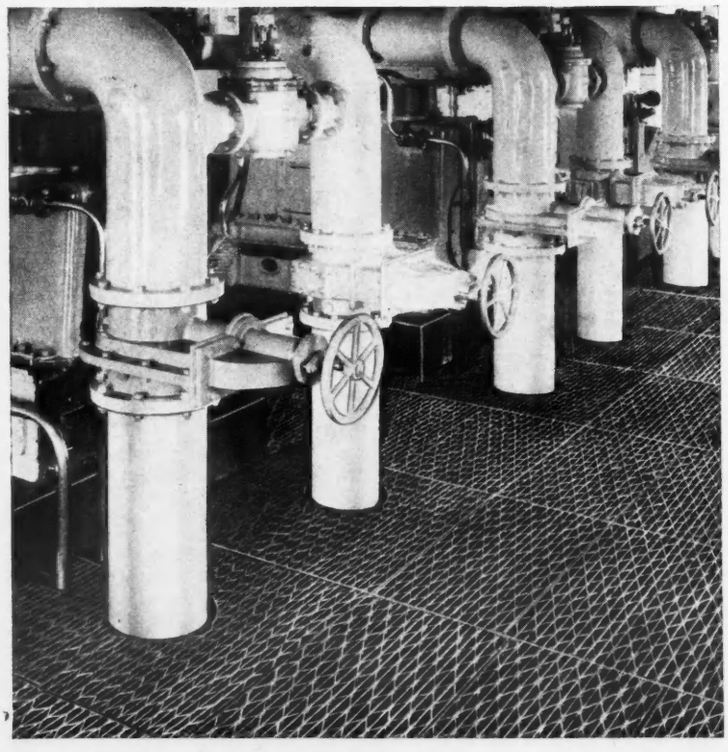

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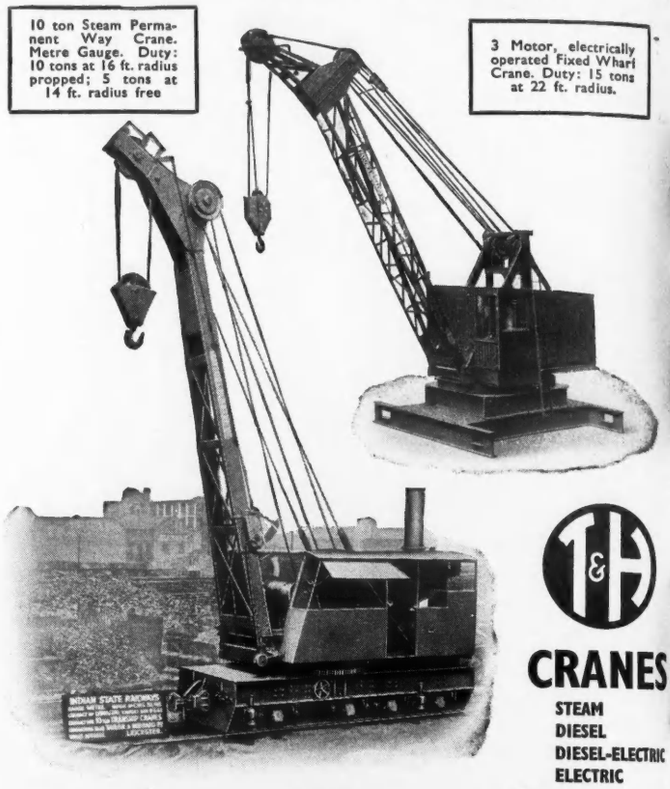

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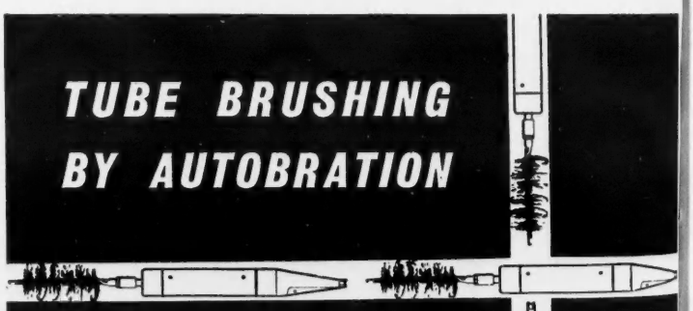

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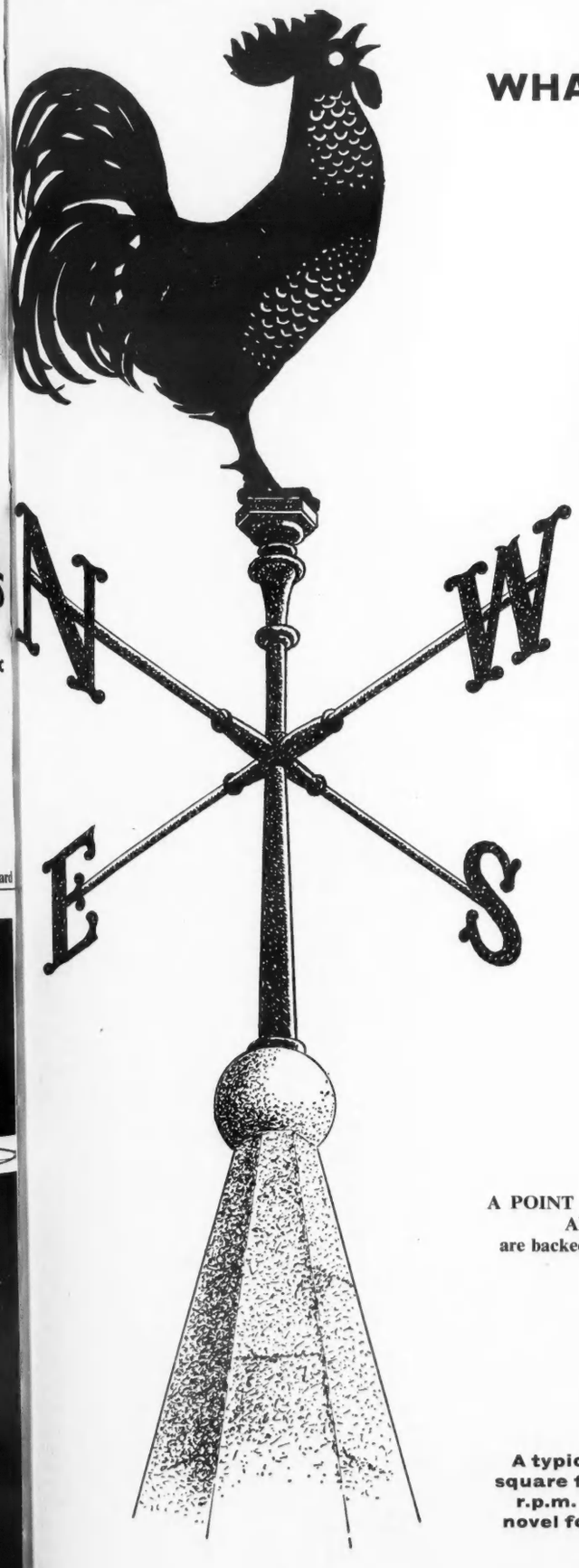

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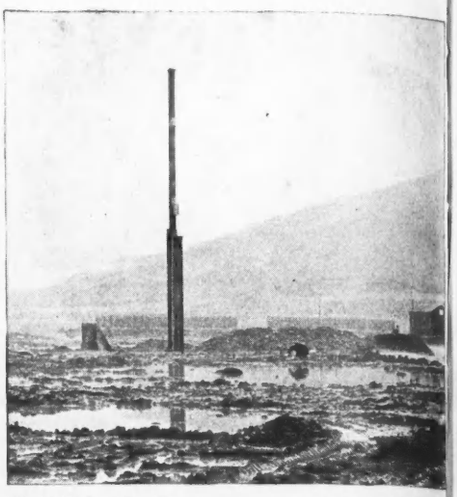
The seven ages of a £14 million steel project

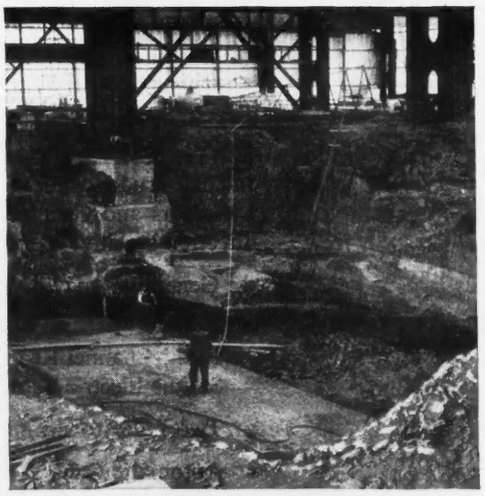
A picture history of Consett's new 4-high Plate Mill

NOVEMBER '58. The site is cleared. In May '58 work began on levelling an enormous platform, over half-a-mile long, in the hillside at Hownsgill. A waste-heap on the site was still burning in places.

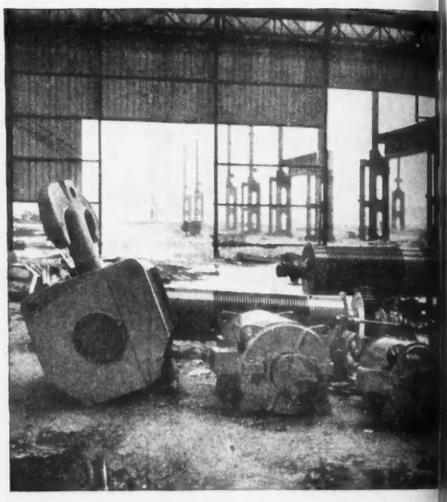


MAY '59. The first column went up on May 4th, 1959. Two million cubic yards of earth had been moved, about 7 miles of new railway track had to be laid, two bridges constructed.

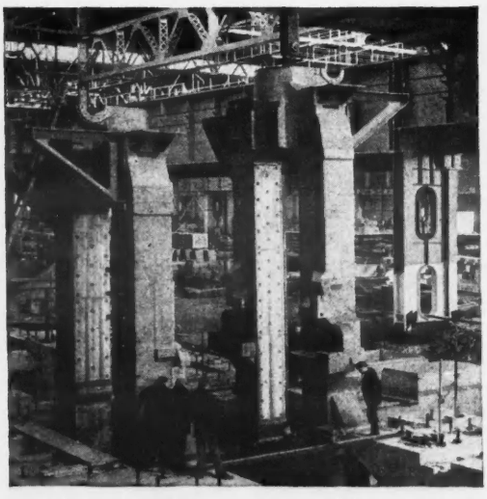
JULY '59. The skeleton rises. 600 men were now at work on the site, and the framework of the mill was well under way. Altogether 11,500 tons of structural steel were to be needed.



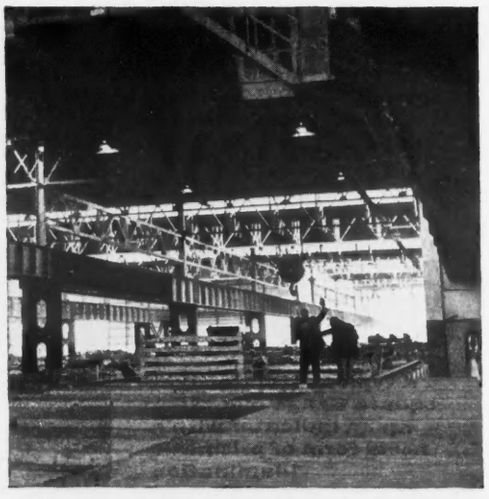
SEPTEMBER '59. Foundations for the mill's equipment were meanwhile being excavated. For the mill stand five huge columns were driven down 50 ft. Hole here is for cross-cut shear foundations.



DECEMBER '59. Equipment for the mill was now starting to arrive. Some of the roof was on, and they were installing the overhead cranes—one of them big enough to lift 150 tons.



MAY '60. Installing equipment. The first job for the overhead cranes was to install the equipment of the mill. Here the housing for the great mill rolls is being manoeuvred into position.



JULY '60. Finishing touches. By now the mill stand, the great shears (capable of cutting nearly 2" thickness of steel) and the cooling banks were all finished.

The next stage of development

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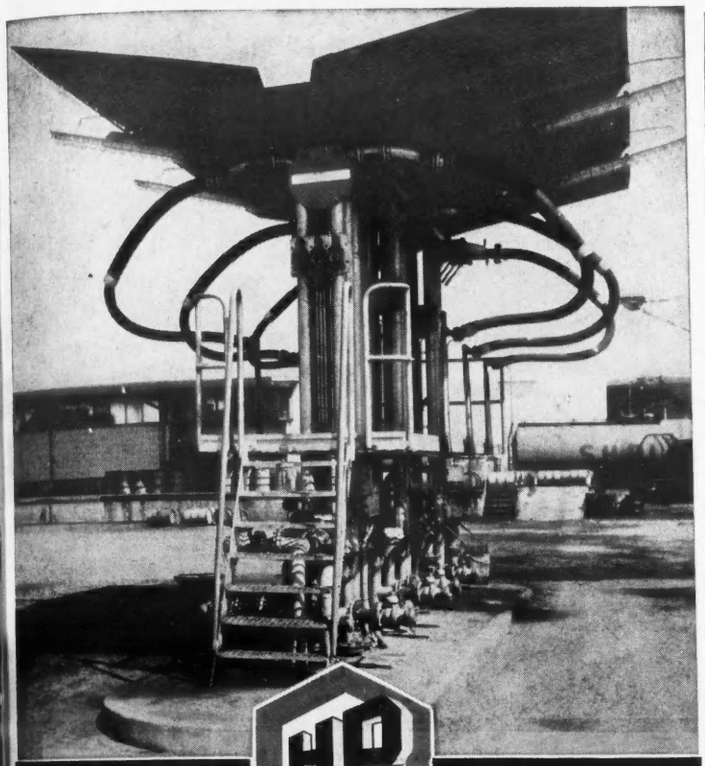

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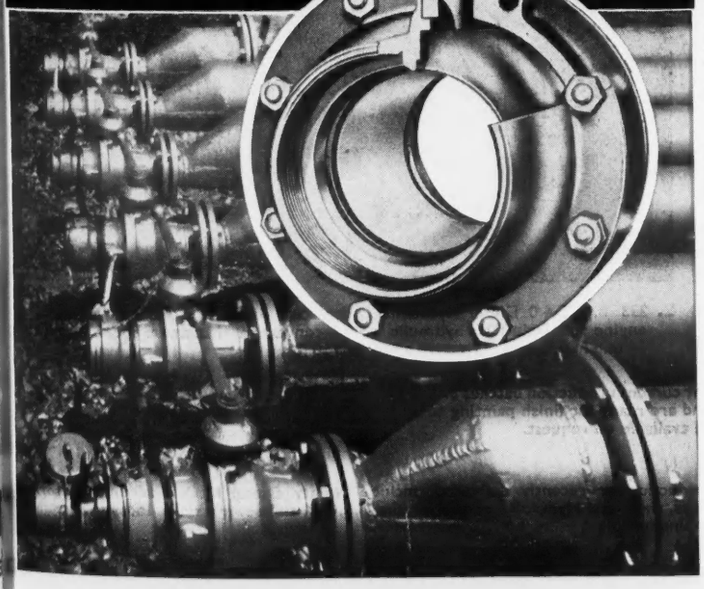

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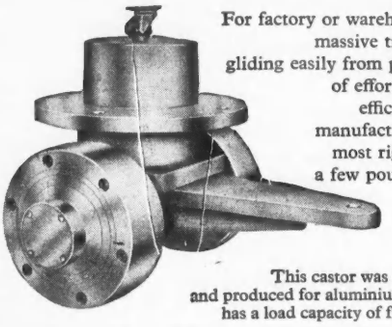

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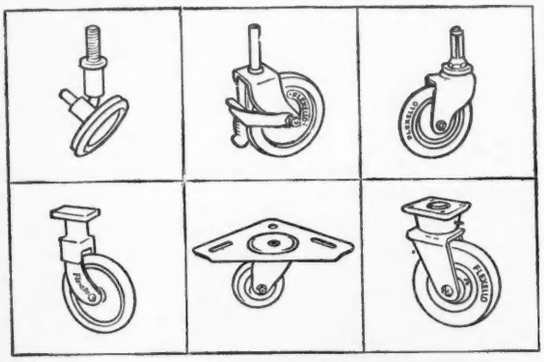

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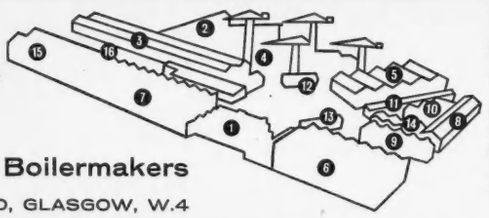

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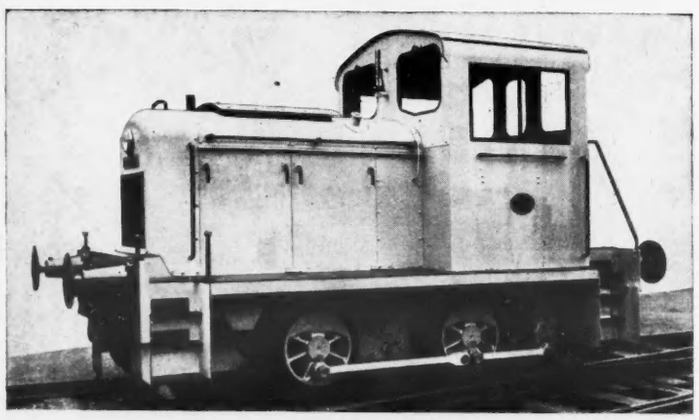

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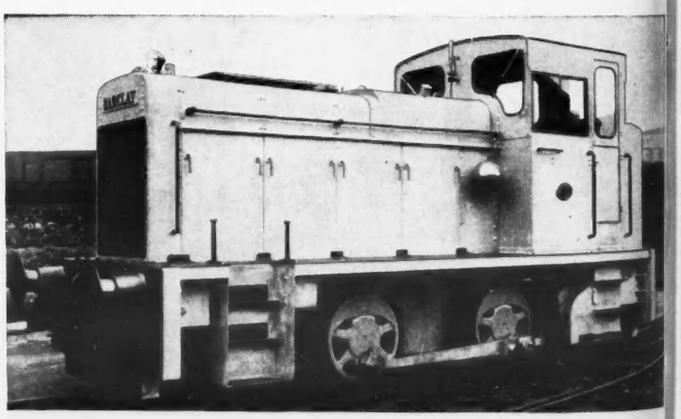

2. 233 h.p. 0-4-0 Diesel Hydraulic Locomotive fitted with Rolls-Royce diesel engine and Twin Disc hydraulic torque convertor. Maximum speed is about 14 m.p.h., maximum tractive effort 21,750 lbs.

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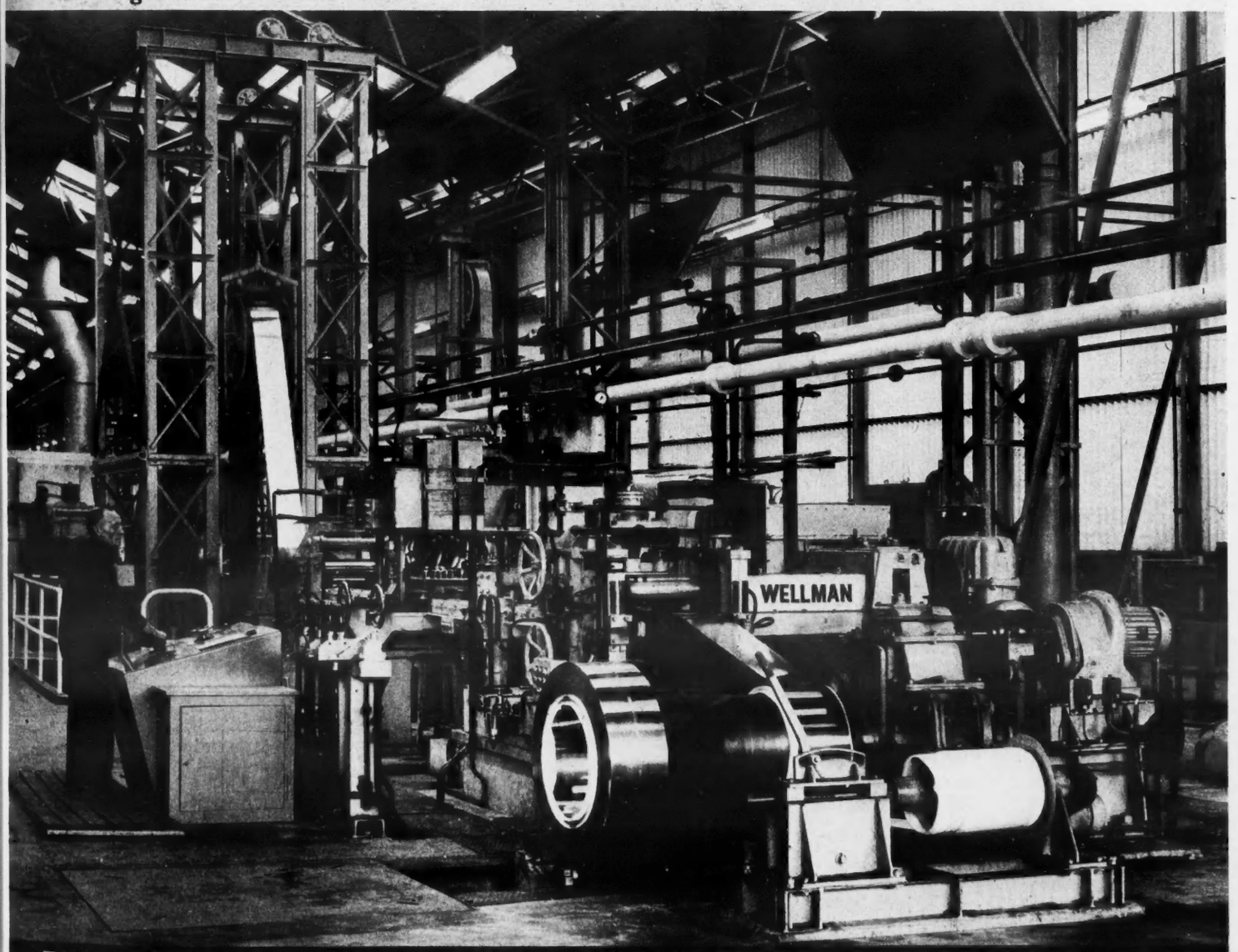

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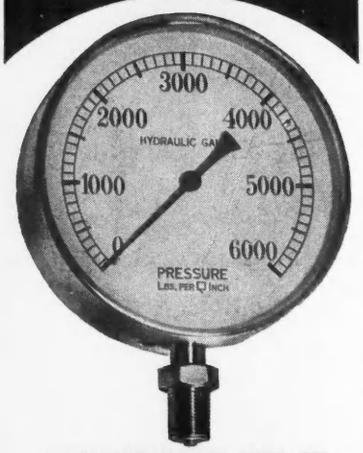

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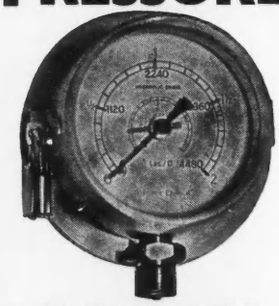

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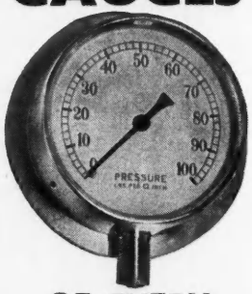

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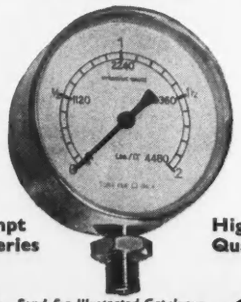

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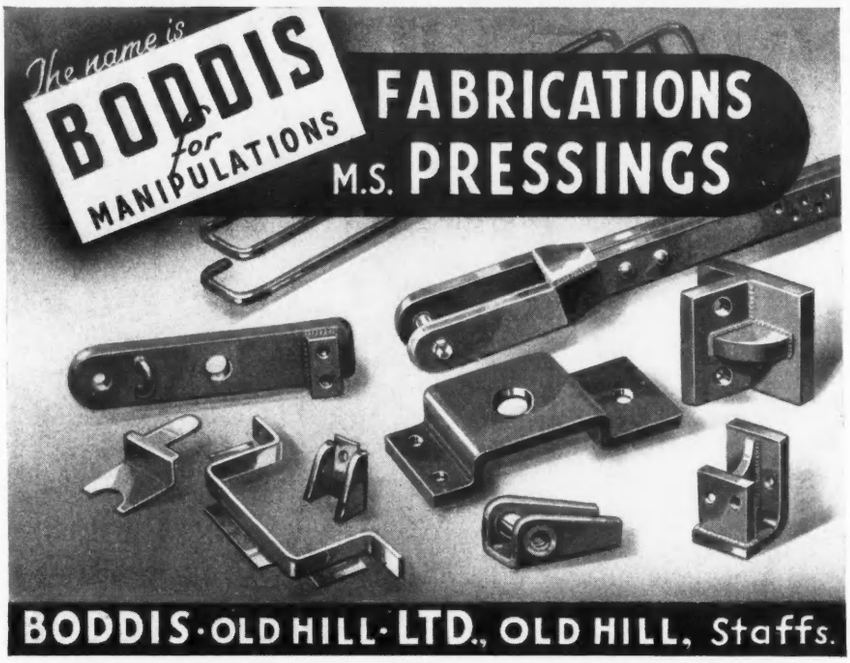

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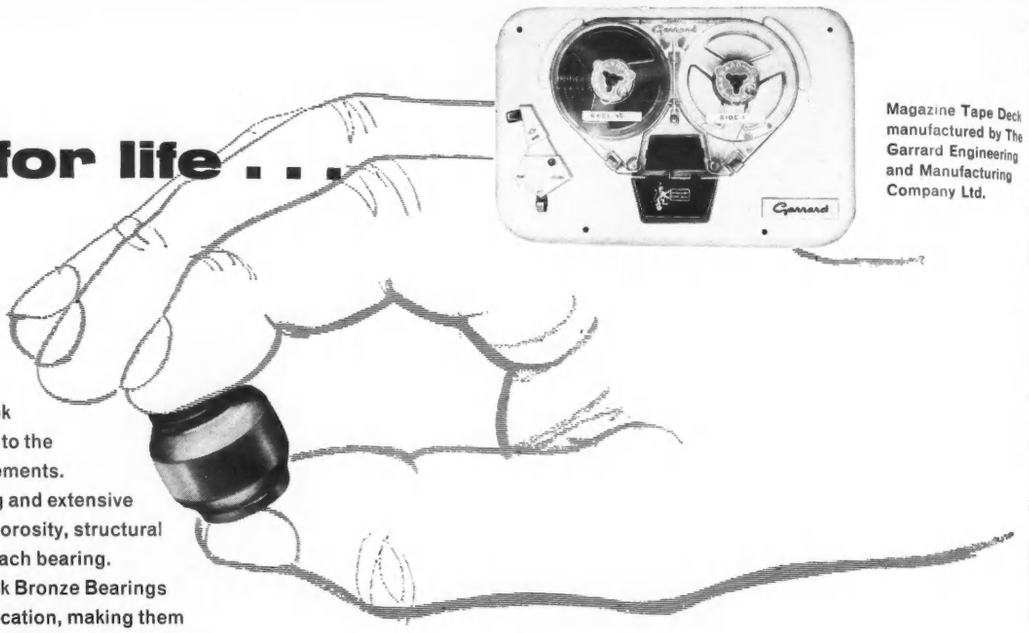

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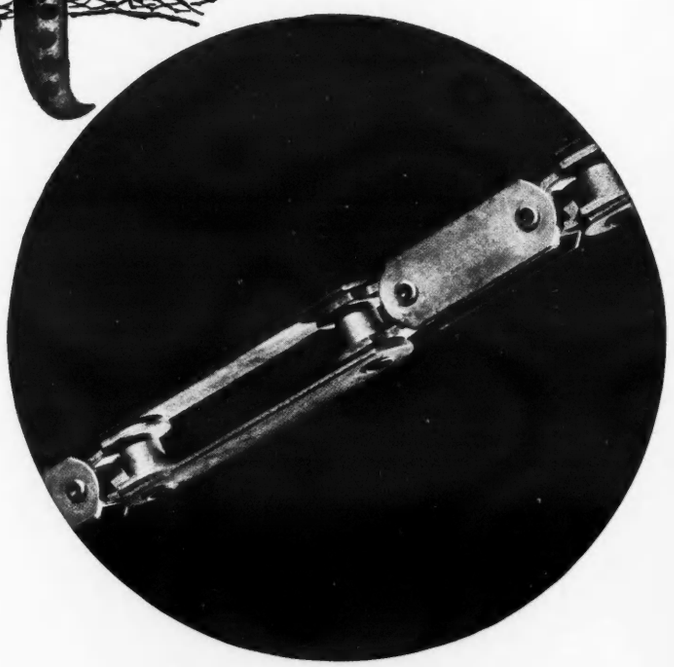

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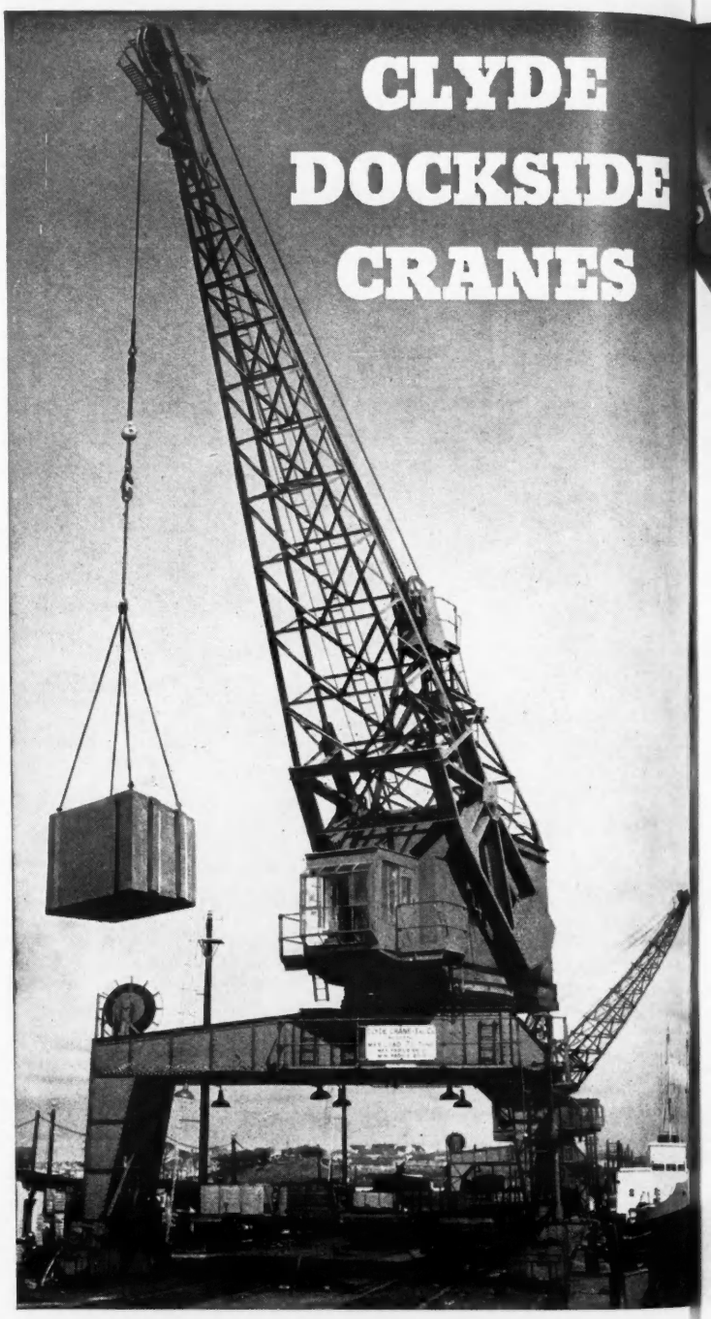

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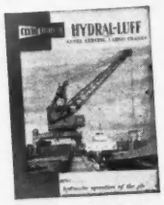

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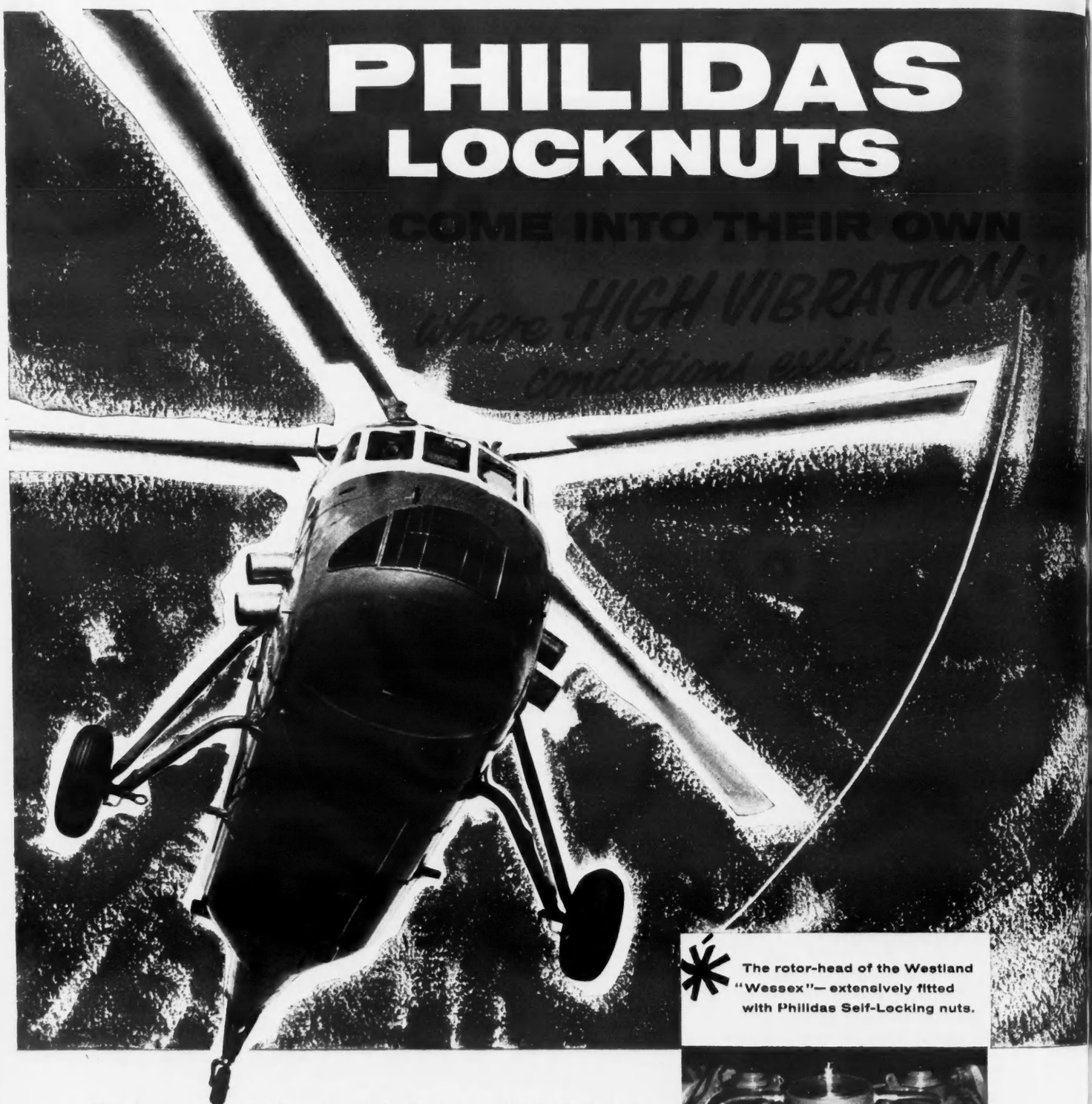

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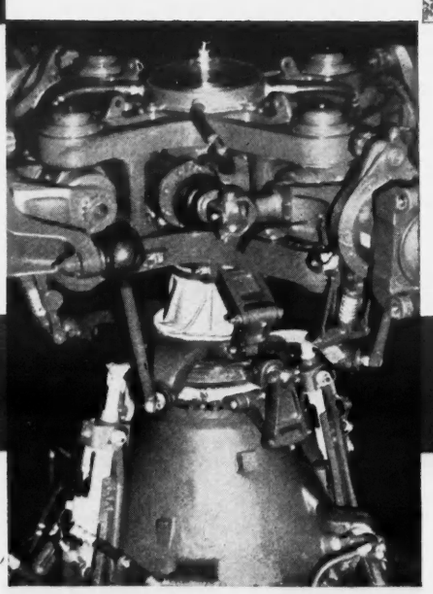

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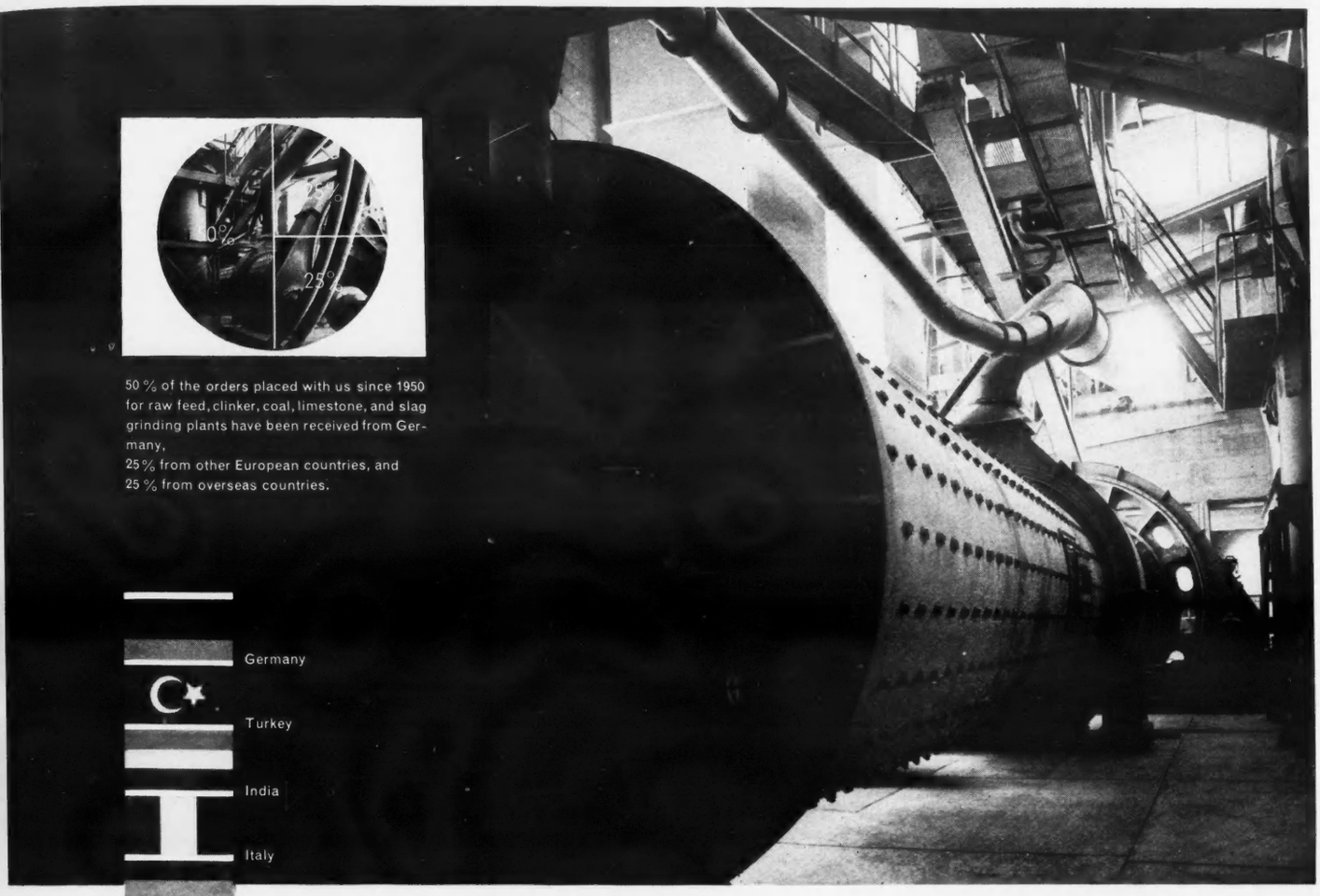

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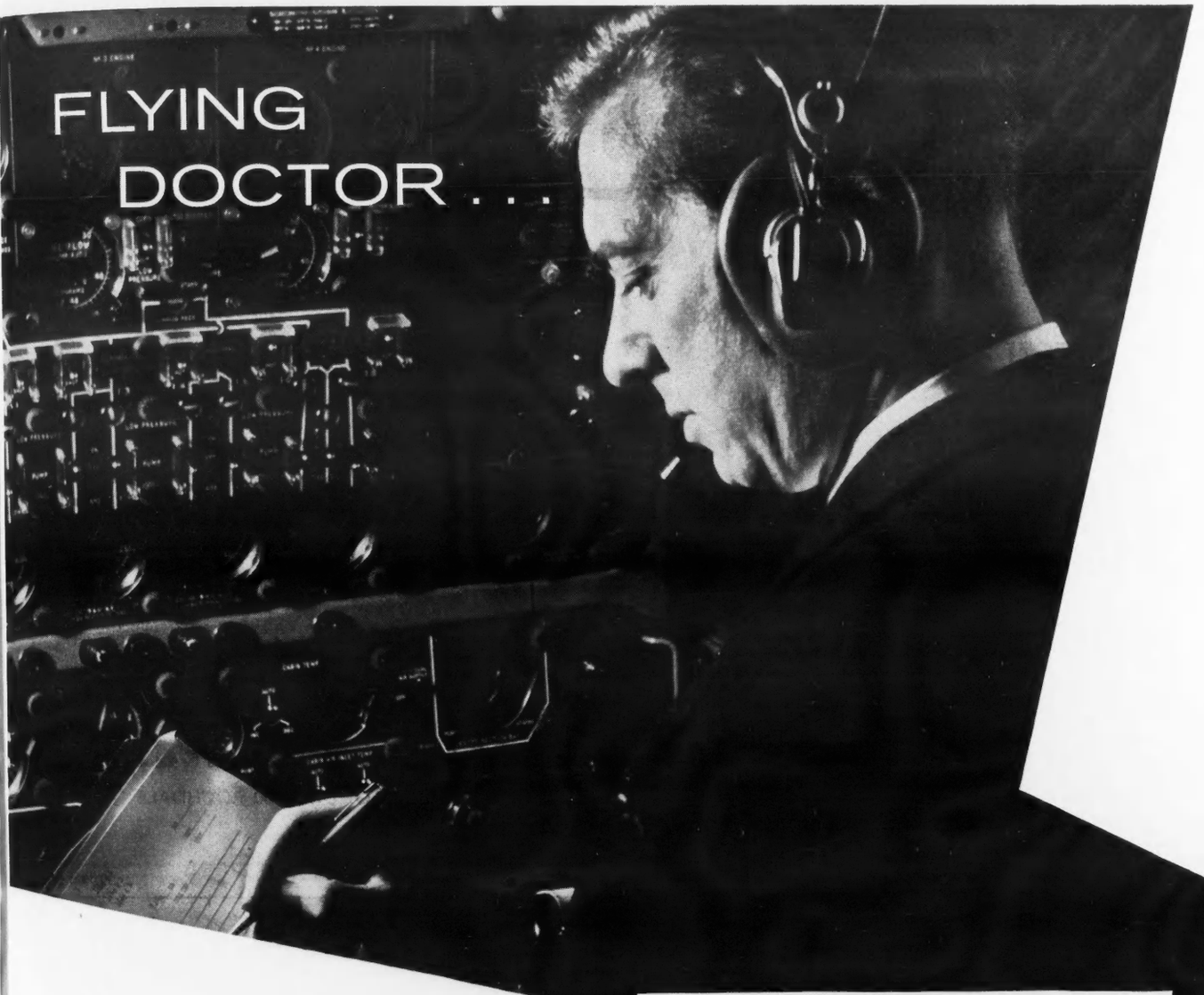

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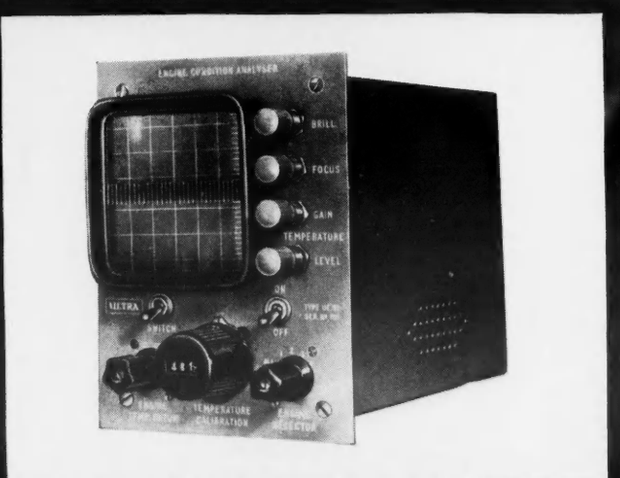

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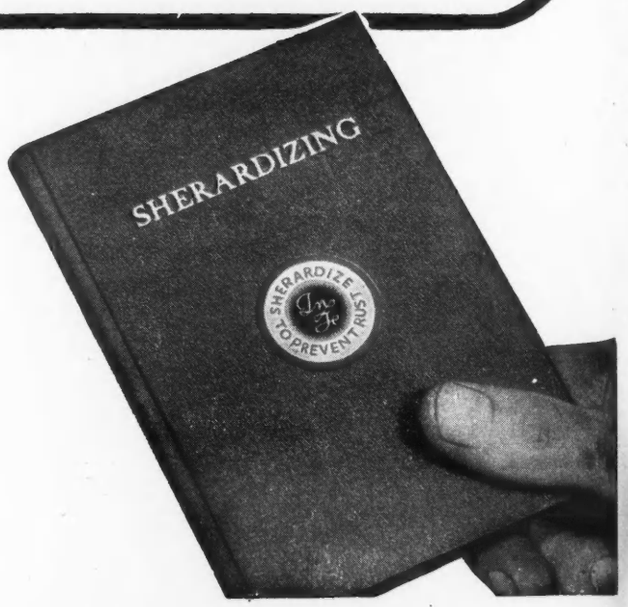

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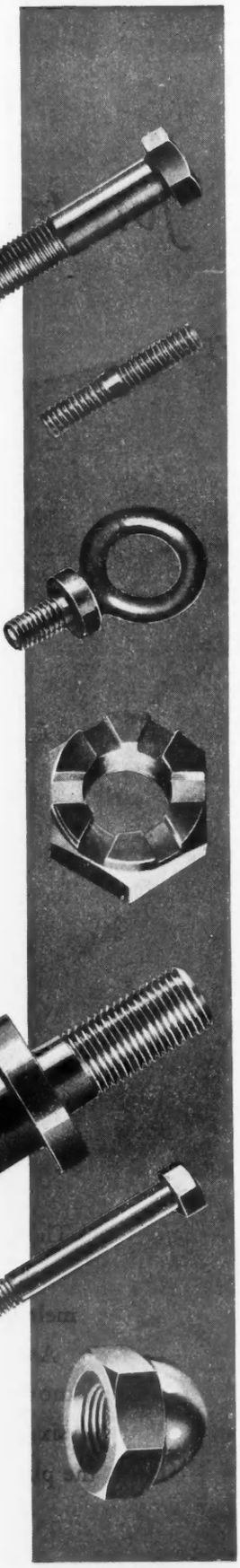

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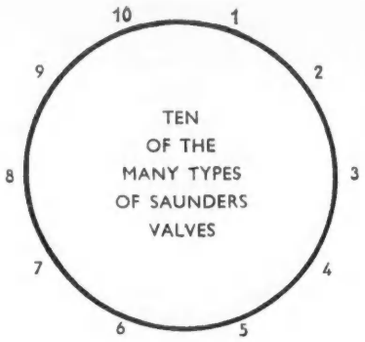

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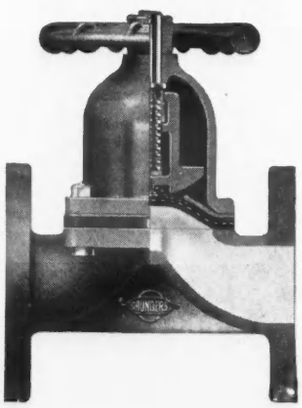

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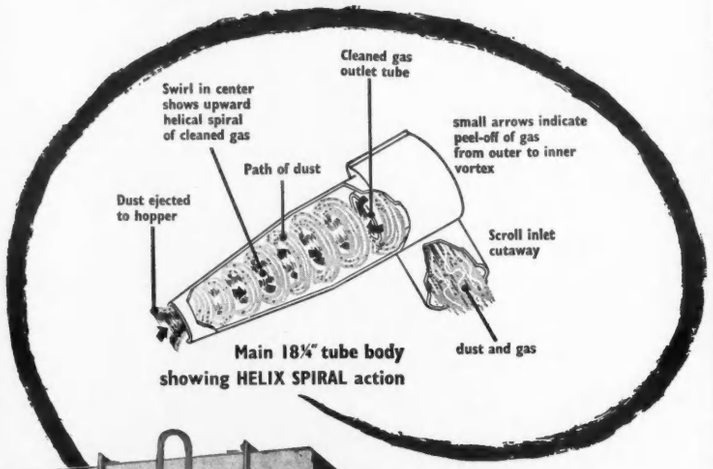
Cleaned gas outlet tube
Swirl in center shows upward helical spiral of cleaned gas
small arrows indicate peel-off of gas from outer to inner vortex
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Dust ejected to hopper
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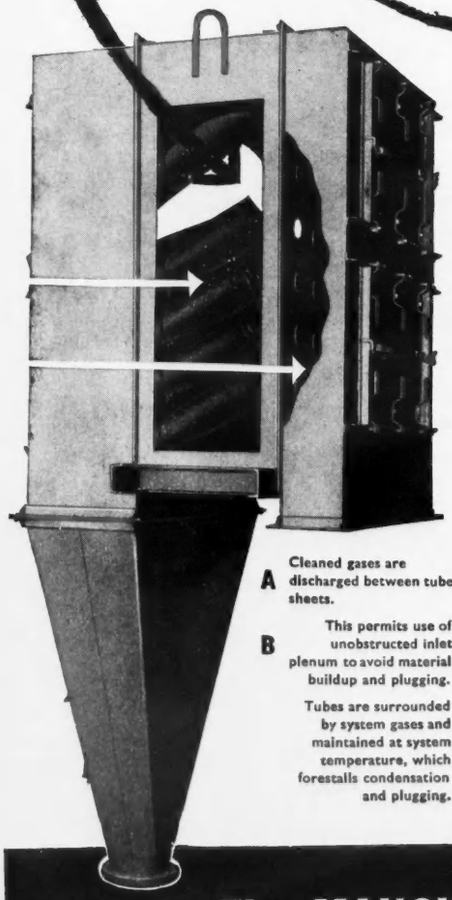
Main 18¼" tube body showing HELIX SPIRAL action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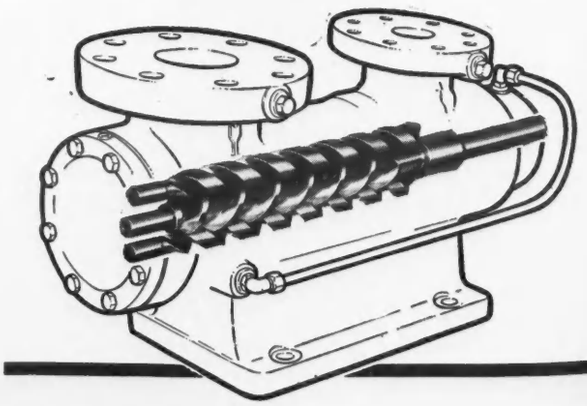

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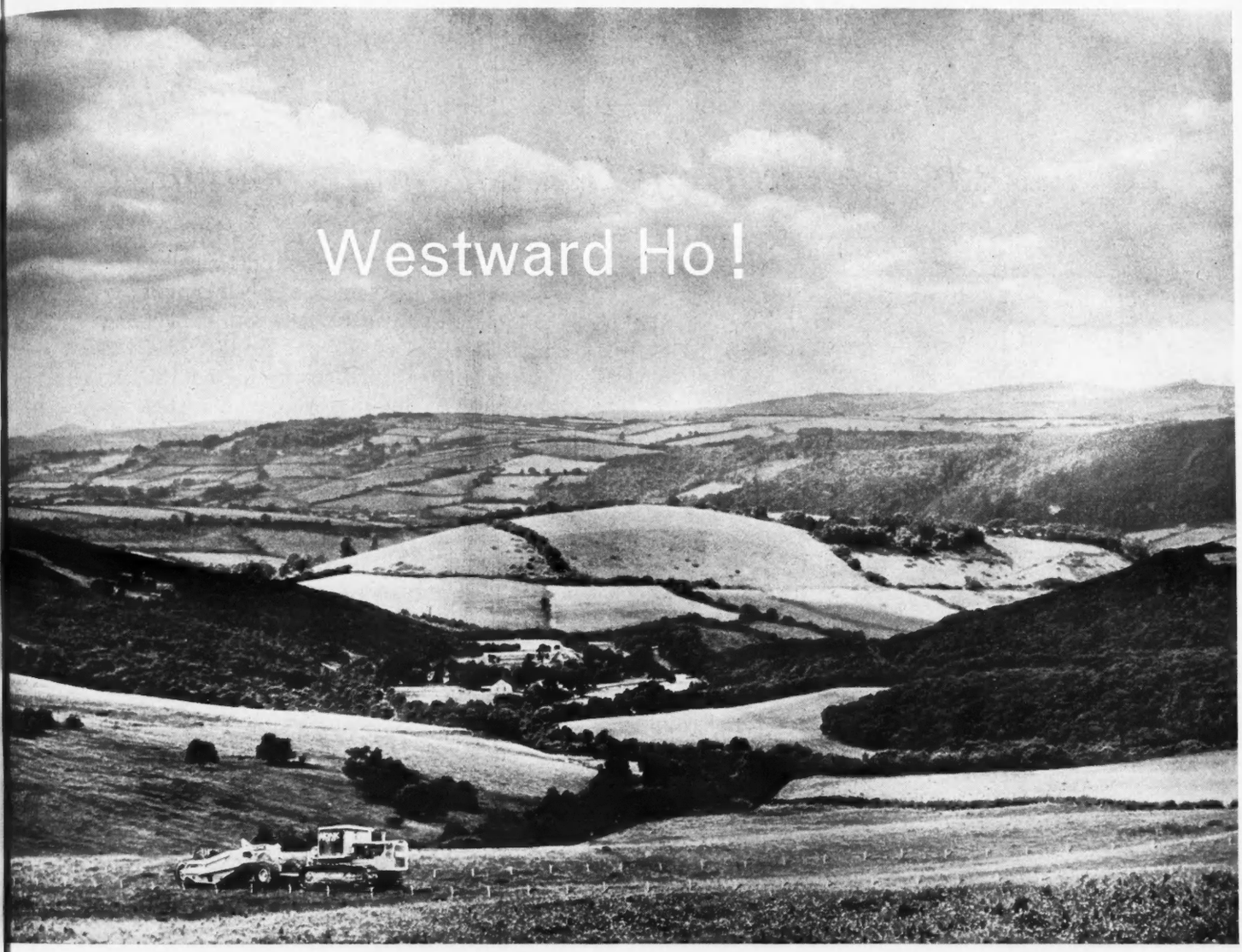

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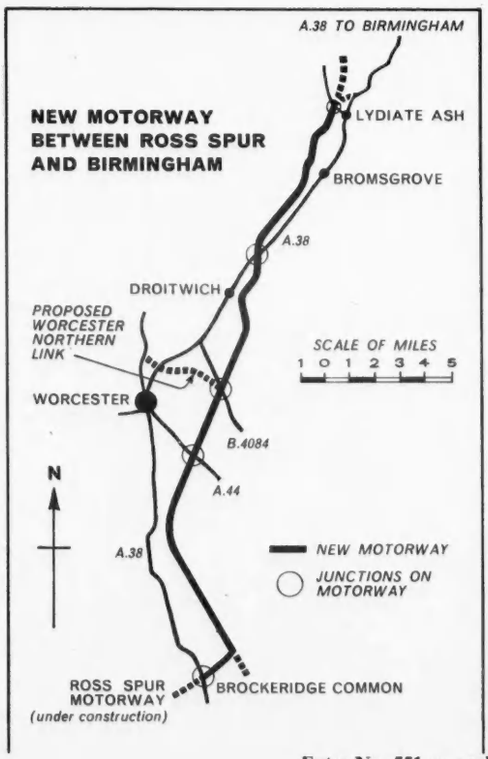

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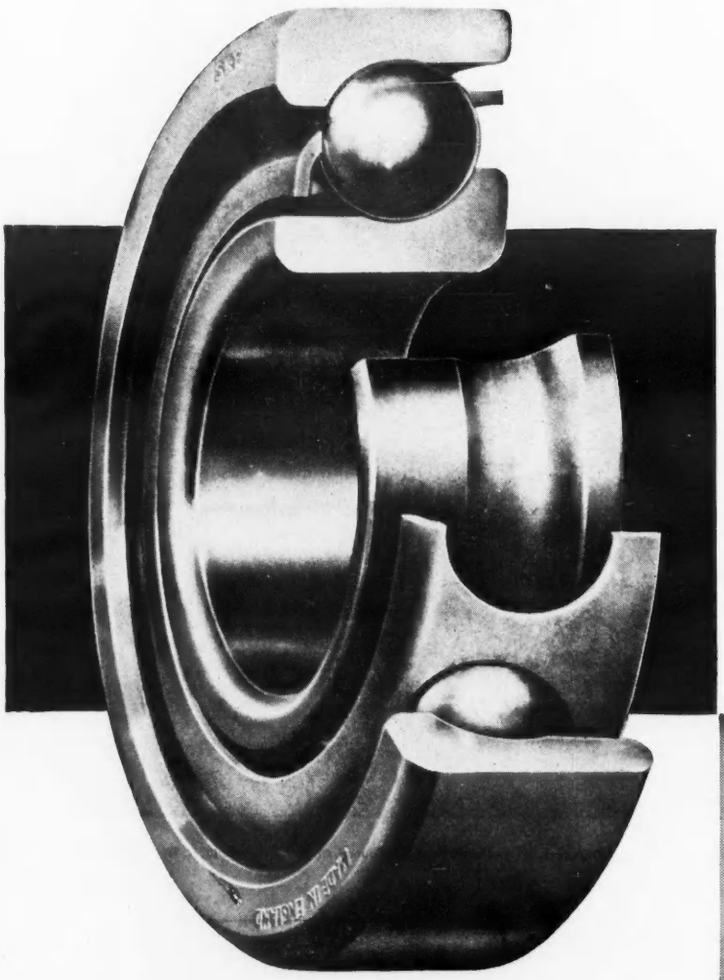

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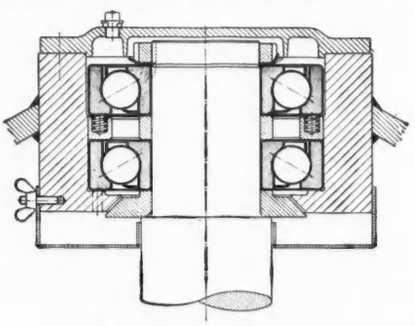

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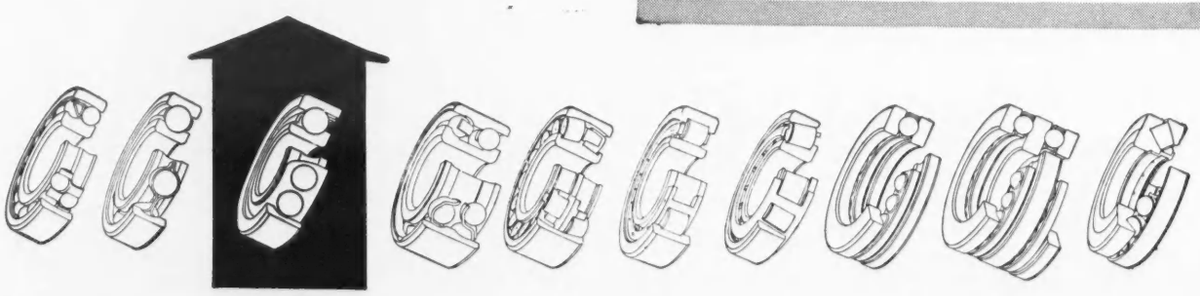

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THE ENGINEER

No. 5452 JULY 22, 1960 Vol. 210

EXPORTS

The provisional figures relating to the United Kingdom's overseas trade in June are not quite so encouraging as those for the earlier months of this year. Exports were valued at £275 million, imports at £384,400,000, and re-exports at £10,300,000, which means that the visible trade deficit was approaching £100 million. Announcing these figures, the Board of Trade says that, after eliminating normal seasonal variation, United Kingdom exports in the second quarter of this year were 3 per cent less than in the first quarter. Over the first six months, however, the monthly average value of exports was 8 per cent greater than the average for 1959. On the other hand, the average value of imports in the first half of this year was 13 per cent above the average for 1959.

This is the situation that was in the minds of the 400 representatives of British industry and commerce whom the Prime Minister, Mr. Harold Macmillan, addressed at a meeting in London last Monday. The meeting was arranged by the Federation of British Industries, the Association of British Chambers of Commerce and the National Union of Manufacturers, organisations which for long have been unsparing in their efforts to advance this country's export performance. The high standard of that performance was not overlooked by the Prime Minister in his speech. The British people, he remarked, had always been traders, and last year they were exporting £10,000,000 worth of goods each and every day. Making allowance for the changes in the value of money, that was nearly double the pre-war rate and the Prime Minister readily acknowledged that it was an " impressive figure ". But he emphasised, just as readily, that it was " still not quite enough ". There was, he urged, " a very real need to do better ". The Prime Minister went on to admit that he was preaching to the converted, but stressed that there was need for broadening the scope of the goods in which this country trades and for expanding the capacity to sell services such as banking, insurance, merchanting, broking, and the provision of finance. Those who were already exporting, he added, must be asked to increase their sales and those who had never tried before must be encouraged to look outwards to the markets of the world. If the country's economy was to be soundly based, the Prime Minister said, there must be changes in the tempo of domestic activity. Firms could not count on an unlimited possibility of expanding home sales at all times. Furthermore, manufacturers owed it to themselves to ensure a firm and continuing balance between the amount of trade they did at home and the amount they did abroad. But it must be kept in mind, the Prime Minister declared, that a world of free competition was strenuous; a strong determination to sell was essential.

We feel sure that the Prime Minister's audience—it included a number of engineers—will cordially agree with all that he had to say on Monday afternoon. It is always helpful when the leader of the Government talks to the leaders of industry and commerce. But the expansion of the nation's export business involves much more than exhortation to do better. Exporting still depends on the ability to provide goods of the best quality at the right price, and at the time promised for delivery; it depends, too, on first-class salesmanship and reliable after-sales service. Industry and the Government are very much alive to all these important factors. But if there could be devised a system of greater incentive to export, that " little bit extra " asked for by the Prime Minister might very quickly be realised.

BRITAIN'S NUCLEAR POWER PLANT PROSPECTS

Sir Christopher Hinton's lecture at the Tercentenary Celebrations of the Royal Society in London on July 20 contained an interesting survey of the evolution of nuclear power plant design. As a survey it is instructive because it gives perspective to developments in a new industry in which technological progress has been so rapid that the word evolution in its classical sense is hardly applicable to it. To-day the position is that the only power-producing reactors in operation in Great Britain are those at Calder Hall and Chapelcross: they, as is well known, are primarily producers of plutonium and generate electricity as a by-product. Their immediate derivatives, however, are the so-called "Magnox" stations, optimised for electricity generation: in Great Britain six of them (Berkeley, Bradwell, Hinkley Point, Hunterston, Trawsfynydd and Dungeness) are under construction, with a total capacity of 2425MW sent out. Although the potentialities of the " Magnox " reactor are by no means exhausted—indeed in the literal sense they have not yet begun to be exploited, since none of the civil stations is yet in operation—research is being directed towards the next stage in reactor development, the Advanced Gas Cooled Reactor (A.G.R.). Such is the rate of progress that the normal engineering practice of preparing and executing a design, based on a prototype, and then proving it by operational experience has been telescoped to an extent that leaves little margin for any errors of judgment at any stage in the development.

That a great deal of useful information is coming out from Calder Hall and Chapelcross is detailed in the sixth annual report of the U.K. Atomic Energy Authority. Some of it will no doubt be applicable to the " Magnox " stations. For example, the prolonged irradiation of the fuel charge in a Calder reactor should provide valuable confirmation of theoretical predictions of conditions that will be characteristic of civil power station reactors. However, much of the information from the Calder reactor comes after the designs of the " Magnox " civil stations have been frozen and can only be confirmatory. Hence these " Magnox " designs must, inevitably, be somewhat conservative, although, as Sir Christopher Hinton said in his lecture, " the margin of ignorance " is being reduced in the later designs. At Calder Hall and Chapelcross the margin was such that the thermal output

of the reactors has been increased, since commissioning, to 15 per cent above the design capacity: the design of the turbines was less conservative and reblading will be necessary if advantage is to be taken of the equivalent increase in electricity generating capacity. Similarly, in the C.E.G.B. power stations a progressive increase in the calculated heat rating can be traced in the later designs, the relative figures being 10·21 (kW per cubic foot of core) at Berkeley, 15·09 at Hinkley Point and 17·46 at Trawsfynydd. The most significant criterion, that of the capital cost per kW sent out, is likely to be reduced from £160 at Berkeley to £133 at Hinkley Point, £123 at Trawsfynydd and £110 at Dungeness. The downward trend in the capital costs of subsequent "Magnox" stations should continue with further improvements in gas pressure, in utilisation of pressure vessel volume and increase in fuel element and coolant temperatures. At some point in the time scale the Advanced Gas Cooled Reactor is likely, because of its higher operating temperatures, to prove more economical than the best "Magnox" reactors: the capital cost of the first A.G.R. stations is estimated, in Sir Christopher's lecture, to be between £95 and £80 per kW sent out, at a generating cost of between 0.55d. and 0.5d. per unit. However, there will probably be a period in which the two kinds of reactor will be of approximately equal merit and orders for A.G.R. stations will be interspersed with orders for "Magnox" stations until ultimately the more technically advanced A.G.R. shows a clear operating cost advantage.

In the meantime, however, the costs of conventional generation are being reduced substantially and, as Sir Christopher observed in his lecture, the research and development effort needed to effect this gain is very much less than the corresponding effort to reduce the costs of nuclear generation. Research and development charges account for about 5 per cent of the capital costs of conventional power plants; in the case of nuclear power plant the figure is in the region of 30 per cent. If one thinks on these lines it is easy to justify the recent decision to slow down the rate of building new nuclear power stations. While the capital costs of these stations remain high and the running costs remain, perforce, unproven the electricity supply authorities (whose task is to use the most economic resources at their disposal, to produce a reliable supply) are strictly correct in seeking to limit their developmental expenditure. What that limit should be is a matter for debate. But the present situation provides a melancholy outlook for the manufacturing consortia: until recently they were five in number and now they have had to close their ranks to re-deploy their resources equitably on the contracts that are in prospect. Thus the newly formed manufacturing groups have the unenviable task of rebuilding their design and construction teams and of renewing their morale, to expedite, as well as they can, the day when nuclear power will come into its own.

REBUILDING CITY CENTRES

Last Friday the Civic Trust held a conference at the Middlesex Guildhall at which the rebuilding of city centres was discussed, a topic which, in one speaker's opinion, was the most outstanding domestic problem that faced the Government, and one that, over the past two years, had become so important as to be a National emergency! In particular, comprehensive redevelopment of central areas was clearly sought, and the advantages, both functional and aesthetic, of this approach as compared with piecemeal development, site by site, were appreciated by all those present. Yet piecemeal development is quite satisfactory to the owner of an individual site in such an area. Official planners are thus faced with the dilemma of reconciling the aspirations of the community as a whole and the rights of the individual "developer". This dilemma is not one which engineers can gaze down upon with complete detachment for by far the greatest single cause in bringing events to their present pass is, of course, that progeny of engineering, the motor vehicle.

In his opening address to the conference, Mr. Henry Brooke, the Minister of Housing and Local Government, suggested that the two central problems were those of ownership and traffic; he was not confident that a solution was clear, and hoped that the conference would suggest some new lines of approach. As to traffic, he said that it was a fallacy to assume that every central area could save its traffic problem by directing its traffic elsewhere. "Put your pencil," he said, "on any central point on the map of a big town. The traffic wants to be there or thereabouts . . . the only margin we have is between 'there' and 'thereabouts'." The contribution which the civil engineer can make to this very problem was dwelt on by Mr. Nicholas, whose remarks are reproduced, in substance, on page 151.

Another point of view expressed by a later speaker emphasised that the problem was not one solely of building roads and garages, but was primarily an architect's problem in that it was a problem of relationships. The city street had become nothing but a smelly conduit for vehicles. New relationships between buildings, pedestrians and vehicles were called for. Indeed, although expressed in different terms, the concept visualised here is not unlike that described by Mr. Nicholas, and very similar to what has been expressed in these leader columns on a number of occasions — pedestrian circulation at first floor level of buildings, pedestrian "enclaves", roads for vehicles only, and so on, which can be summed up as the segregation of the pedestrian from the vehicle in as flexible a manner as possible, so as to create graceful surroundings and enhance amenity on the one hand and attain convenience and cheapness of movement on the other. It was this approach which seemed to get the most support at the conference, and was expressed in its most idealistic form by Mr. Chamberlin (architect for the Barbican scheme) when he spoke of redesigned central city areas as "a feast for the eyes and enrichment for the spirit". Though this may sound a counsel of perfection, it may well be that a lower standard is not compatible with an age of such technical mastery that it offers promise of almost unlimited material prosperity. So far in discussing the conference we have avoided comment on the mass of legalistic planning problems—which are indeed complex and formidable—which bar the road towards the ideal solution. Perhaps they can be left the more happily undiscussed in a journal concerned with engineering. They are, however, commented upon quite forcefully in the brochure which the Civic Trust prepared for the conference, and those interested will find much food for thought both in the brochure and in the conference proceedings. We only wish to point a moral on the engineering side, namely, that it is a service perfected by engineers, the ubiquitous motor vehicle which has virtually destroyed the traditional architectural balance and pace of living in the urban environment. Not until harmony is established between the two—the urban environment on

the one hand and the vehicle on the other—will the full benefits of both be enjoyed and the hazards of road traffic minimised. The same may well hold true for other engineering devices, too, and their relationship to the environment in which they operate.

CLASSIFICATION OF WARSHIPS

When Princess Alexandra launched H.M.S. "Devonshire" on June 10, she did much more than launch a fighting ship. She began a new era for the Royal Navy by launching the first British vessel to be armed with guided missiles. Later this year—on Trafalgar Day—H.M. The Queen will emphasise this new era when she launches the nuclear-powered "Dreadnought"—an entirely new type of underwater vessel, able to proceed submerged for as long as desired and as fast as required. To find a parallel for this revolutionary advance, it is necessary to go back a hundred years, when Britain launched her first ironclad —H.M.S. "Warrior." Even so it may well prove that 1960 was a more revolutionary year than 1860. The frigate "Warrior" was armed with Sir William Armstrong's new 110-pounder breech-loading rifled gun. The old cumbrous gun-carriage, virtually unchanged since Nelson's day, was replaced by a fixed stand, the gun running backwards and forwards in a slide, with a pivot for training the gun fore and aft, placed over the centre of the gun. The "Warrior," indeed, could have blown any of our then existing battleships out of the water. None the less, she was still armed with the same type of weapon—the gun. Moreover, though she was equipped with a steam engine and propeller as auxiliary to sail, this was no new form of propulsion such as we have to-day with nuclear power. Already in 1860, the Royal Navy had thirty-two sailing ships-of-the-line built or converted to use a steam engine.

The parallel is perhaps more striking in that the Board of Admiralty of 1860 were faced with the identical problem which faces the Admiralty to-day —how to classify as a type ships which are wholly different from their predecessors. A hundred years ago ships-of-the-line were classified as "First-Raters," "Second-Raters," &c., according to the number of guns carried. It seemed ludricous to classify the "Warrior"—the most powerful ship afloat—as anything less than a line-of-battleship merely because she carried fewer than the stipulated number of guns. Accordingly, after much thought the Board decided that the size of her complement was to be the determining factor. She was classified as a "Fourth-Rater." To-day, the Admiralty, in classifying the "Devonshire" as a destroyer, seem to have lacked the logic and wisdom of their predecessors a century ago. Her function is to act as an anti-aircraft and anti-submarine escort for a Task Group. Destroyers, it is true, were used as anti-submarine escorts during both world wars. But the term destroyer was originally applied many years earlier to relatively small ships designed to destroy French torpedo boats intended to sink the British battlefleet at night by torpedo attack. With the elimination of the battlefleet why perpetuate the classification and apply it to ships of over 5000 tons which are about the same size as many of the cruisers we had until recently on the active list? Indeed, in any credible war of the future, when we may expect attacks on our trade routes, the "Devonshire" class, with their auxiliary gun armament of four radar-controlled 4.5in guns, will soon be the only vessels available to supplement the three "Tiger" class cruisers in identifying and dealing with raiders armed with 6in guns. Why not call "Devonshire" an "escort cruiser" and thus make it clear to the British people what H.M. ships are intended to do?

Correct classification of ships becomes of greater importance with the growing realisation that a mutually destructive total war in Europe is becoming less credible. The credible war of the future will be fought, as hitherto, to persuade an enemy to change his policy and not for the purpose of mutual annihilation. Russia has sufficient naval forces to engage in a maritime war on a large scale and it is essential that the N.A.T.O. navies should be organised on a basis of interdependence. The protection of the trade routes is likely to be of paramount importance and the smaller powers should assume greater responsibility for mine clearance in coastal waters and focal areas, leaving the "Big Three" to concentrate on craft required for trade protection. Depending on the effectiveness of the "Skybolt" and the vulnerability of the bomber which launches it, it may also be necessary for the British and French Navies to supplement the United States seaborne deterrent bases. The United States and France are in fact already contemplating surface ships partly armed with ballistic rockets and it is to be hoped that instead of building deterrent submarines costing £40,000,000, the larger ships built by Britain to safeguard the trade routes will also be capable of carrying out a deterrent role. Ships of the N.A.T.O. navies could then be classified according to function in ten categories, including, it will be noted, two for the underwater vessel —the nuclear-powered submarine which habitually navigates submerged, and the submersible which has the ability to submerge when required. The following categories would make the purpose of each type of ship intelligible to everyone: deterrent carriers (U.S. vessels operating medium-range bombers); deterrent submarines; carriers; cruisers; escort cruisers; escort frigates; submarines (nuclear powered); submersibles (diesel electric-drive); destroyers (existing type will not be continued); and minesweepers.

The Engineer—100 Years Ago (JULY 20, 1860)

"NOTES FROM NEW SOUTH WALES."

"Various appropriations required for the further extension of the telegraphic system throughout the colony have been voted by the Legislature. The most important of the new extensions determined on is that from West Maitland to the boundary of Queensland, by way of Singleton, Scone, Murrurundi, Tamworth, Bendemere, and Armidale, a length of about 300 miles. Only a portion of this line will be at present proceeded with, its completion being contingent upon the engagement of the Queensland Government to continue the line to Brisbane. There is little doubt that one of the first acts of the Legislature of the new colony will be to authorise the connection of their metropolis by means of the telegraph with the other capitals.

"Another important extension authorised by the Assembly is that from Gundagai to Deniliquin by way of Wagga-Wagga, to bring this colony in connection with the Victoria and South Australian systems at Echuca, by way of Castlemaine and Ballarat. This extension will be about 200 miles in length, and will include the purchase of the line already in use between Deniliquin and Echuca. The other extensions consist of lines from Bathurst to Orange, a distance of 25 miles; and from Hartley to Mudgee, a distance of 80 miles. A second wire for the intercolonial line has been completed to Albury, the boundary of New South Wales, but the Victorian Government have at present failed to carry on the wire to Melbourne."

Rockets and Space Flight up to 1960

By JOHN E. ALLEN*

No. II—(*Continued from page 101, July 15*)

Recent rocket research and development is reviewed mainly in two categories: first, the advances in rocket motor technique, engineering and production; and, secondly, the characteristics and uses of rockets in missiles, space exploration vehicles and miscellaneous applications. Some attention is also paid to the important engineering developments in ground handling and launching gear of rockets and space vehicles. As there is now a very wide range of possible electrical propulsion systems under consideration for space flight, an attempt has been made to classify these in relation to their principles of operation, with indications of the present state of the art, where this can be judged from such details as have been officially released.

ROCKET PROPELLED VEHICLES

MAJOR technical progress in rocket vehicles is discussed in the following groups:

Large ground-launched ballistic missiles.
Mobile ballistic missiles.
Large interceptor missiles.
Space flight.

United States Rockets

Surface-Launched Ballistic Missiles.—The Convair "Atlas" I.C.B.M., which has been under development for some years, reached operational capability during the latter half of 1959.[75] An "Atlas" (No. 10B) was used for Project "Score," the communication satellite experiment of December, 1958. The latest design of the missile has an overall height of 86·5ft, a diameter of 10ft (16ft with the two jettisonable boosts attached), and a launch weight of about 260,000 lb. The thrust at launch is about 390,000 lb, the re-entry speed is approximately 16,000 m.p.h., and the range is over 6000 miles.

Most of the airframe consists of a propellant tank 60ft long and 10ft in diameter, of pressurised monocoque construction in very thin Type 301 stainless steel sheet. New techniques for the handling and welding of thin stainless steel, in gauges as thin as 0·010in,[76] have had to be developed. The helium-argon gas mixture used for welding has introduced other problems; extra pure helium is needed, the quality of each supply of which is checked by a test weld; and the fact that helium would penetrate some porous castings unless they had been impregnated with a synthetic plastic material. The extreme care needed to produce these "metallised balloon" structural shells has introduced techniques certainly found nowhere else in structural engineering.[76] (Fig. 16). Figs. 17 and 18 show the more robust Douglas "Thor" I.R.B.M. of light alloy construction.

An early "Atlas" cone (Mark 2), which was blunt and of the copper heat-sink type, has now been replaced by a more pointed ablative cone (Mark 3) recently developed by the General Electric Company, thus permitting a higher re-entry speed and increasing the difficulty of interception.

The "Minuteman"[77] I.C.B.M. has three solid rocket stages, stands about 55ft high and has a diameter of about 5ft, a launch weight of under 80,000 lb, and a range probably of over 6000 miles. Aerojet General and Thiokol share the responsibility for rocket engine development as a result of contracts placed early in 1959. The nature of the propellants has not been divulged. Development, by Boeing, has been rapid. A tethered first stage has been tested, and several ground level and one underground silo launchers have been constructed. It is planned that most of the missiles would be capable of being launched either from underground silos or railway launchers, and operational capability is expected by late 1962.

The Martin "Titan" I.C.B.M. was planned later than "Atlas," and has significant differences in construction. The missile has two stages, both of which are monocoque

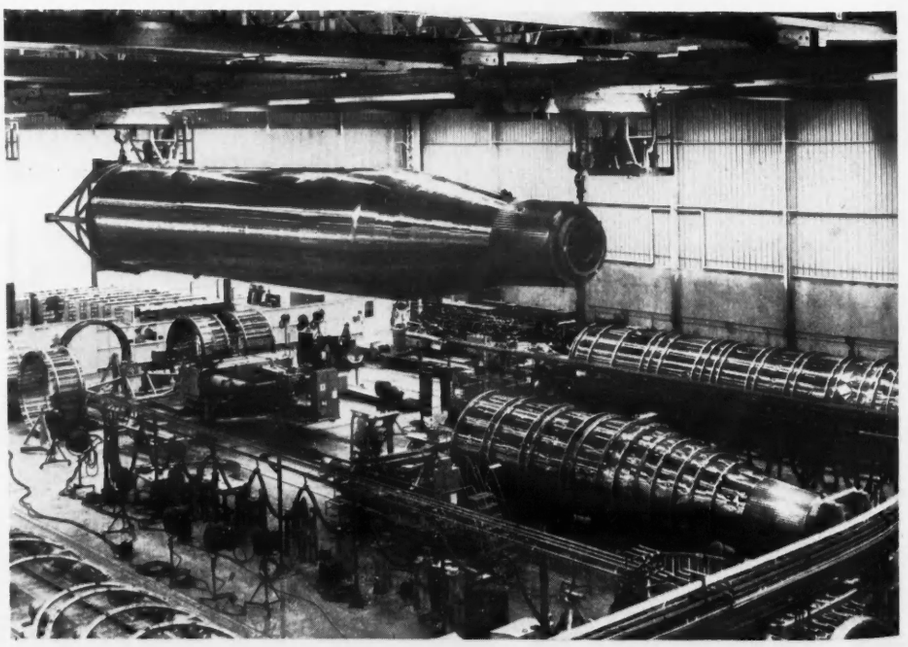


Fig. 16—This 60ft tank for a Convair "Atlas" inter-continental ballistic missile has been pressurised to enable it to hold its shape. The tanks being assembled below it still have supporting rings around them

* Member, American Rocket Society, Member of Council, British Interplanetary Society.

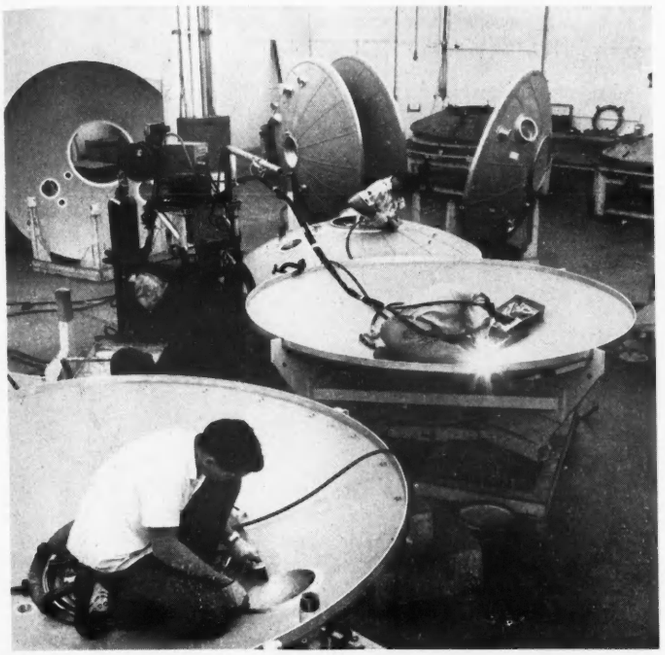


Fig. 17—Tank bulkheads for the light-alloy Douglas " Thor " being fabricated

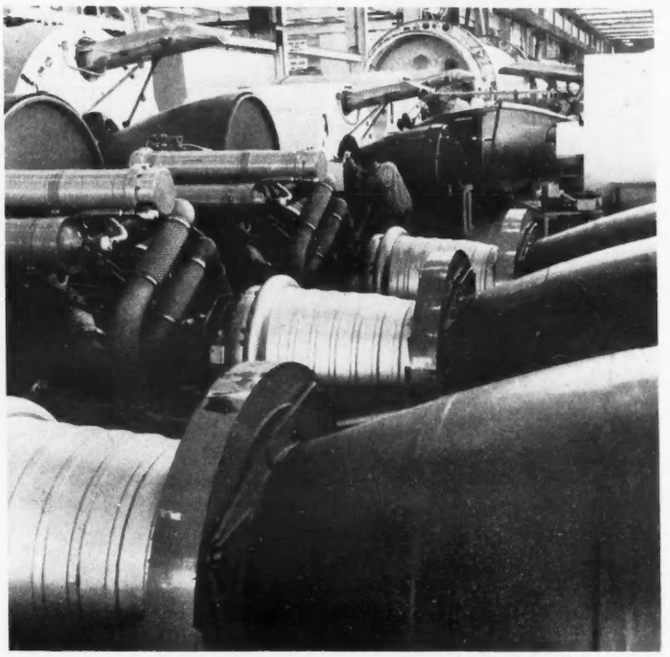


Fig. 18— Rocketdyne engines before and after assembly on " Thor " missiles

cylinders of an aluminium alloy rich in copper, and the overall height is 99ft, greater than that of any other missile produced in the Western hemisphere. The diameter of the first stage is 10ft, the launch weight is about 210,000 lb, and the thrust at launch is some 300,000 lb. " Titan " was originally planned for a range of over 6000 miles and re-entry speeds of about 16,000 m.p.h. According to unofficial reports, a range of some 10,000 miles could be achieved with a high energy second stage. Avco, the contractors for the present blunt heat-sink nose, were awarded a further contract for the development of a more slender, pointed cone having less air resistance, better aerodynamic stability and higher re-entry speed. The heat input would be greater than with the blunt nose and this is dealt with in an ablation surface, possibly of Teflon. It was used in a " Titan " firing last December. The missile is at present guided by a radio-inertial system, but a pure inertial system of advanced type will eventually be used ; a system is under development at the Massachusetts Institute of Technology. The first stage is propelled by an Aerojet-General rocket engine, with twin chambers, using liquid oxygen and RP-1. As already noted, the second stage may be powered by a nitrogen tetroxide-hydrazine engine. " Titan " is to be launched from underground silos which will house the missile in a vertical position and contain an elevator to raise the missile and launcher to the surface ready for firing.

In spite of a successful flight test early in 1959, there were a number of spectacular failures of " Titan " test vehicles, some on the launcher. A remarkable explanation of the failure of December 12 was reported in *Aviation Week*.[78] The missile was destroyed by its own destruction system four seconds after " zero," when a relay was vibrated and closed. The vibration resulted from the combined effects of the rapid engine start and the firing of four explosive bolts which retain the missile until thrust has developed, ensuring a full-thrust lift-off (usually after six seconds). The relay was near the skin in a region where even a change of position of a few inches can make a radical difference to the vibrations experienced.

Mobile Ballistic Missiles.—The evolution of very small nuclear warheads, small guidance equipment and bold design philosophy has led to a new class of ballistic bombardment missiles so small that they can be launched from either aeroplane or submarine.

" Polaris," the submarine weapon, has been shown before 1959, but considerable development was noted during the year. Photographs and some facts were disclosed of the air-launched A.L.B.M. " Bold Orion " (later " Skybolt ").

" Polaris " is a two-stage solid rocket pure inertially guided fleet ballistic missile. Aerojet General are responsible for the propulsion (Fig. 11 *ante*) and the project system manager is the Missile Systems Division of Lockheed Aircraft Corporation.

Interesting materials problems arise in the manufacture of very thin steel motor casings (reportedly 0·070in thick), the need to prevent corrosion and ingress of sea water to internal systems during under-sea launching and the use of beryllium in the structure and re-entry head.

No official weight or dimensional data[79] have been released but various sources—presumably from photographic analysis—suggest a total length of 30ft and base diameter of about 5ft. Weight is quoted in the region of 25,000 lb to 28,000 lb.

The guidance system, claimed to weigh only 200 lb, is the responsibility of General Electric Company, of Pittsfield, assisted by the Massachusetts Institute of Technology.

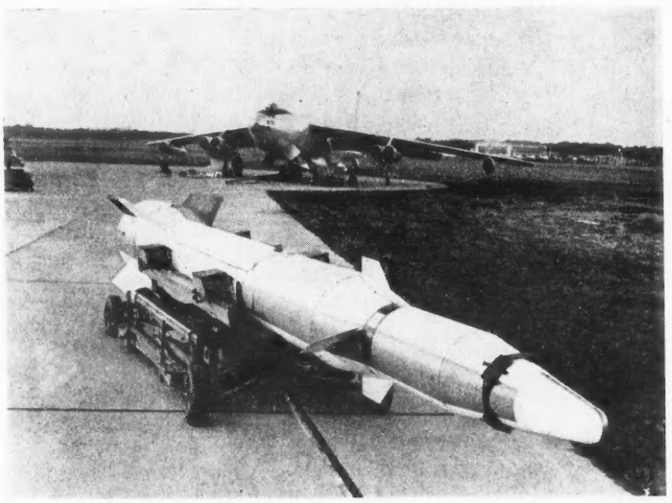
The accurate Ship Inertial Navigation System (S.I.N.S.) by Sperry Gyroscope Company and Autonetics Division of North American Aviation has been on test in the " Compass Island " (a converted cargo ship) and permits accurate attack on targets up to ranges of 1500 miles. Early model firings and captive tests of underwater launches were in hand before 1959 but last year saw the successful launching from Cape Canaveral of several operational type vehicles to ranges of 900 miles. Apart from the development of steering control and accuracy of burn-out velocity, " Polaris " has introduced many new problems associated with underwater launching. To assist experiments of launching from ships, a Ship's Motion Simulator was made by the Baldwin-Lima-Hamilton Corporation and real launch tests are to be made from U.S.S. " Observation Island."

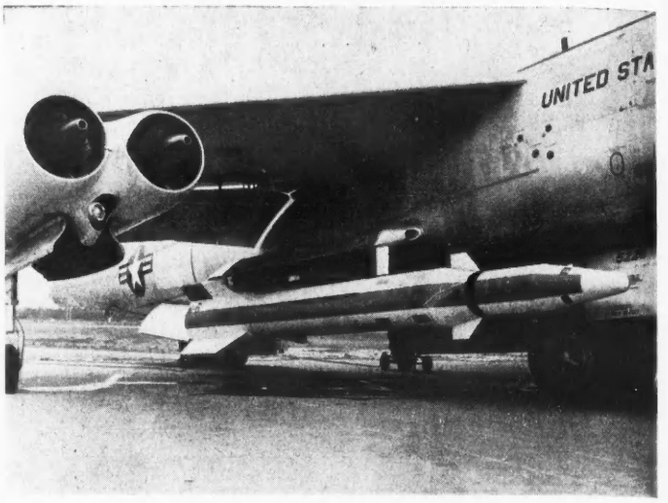
Early in 1959 it was announced that five " Polaris " launching submarines (S.S.B.N.), each carrying ten weapons, were under construction. The first—the U.S.S. "George Washington" was launched in 1959. Early versions of these submarines cost 110 million dollars—later this will reduce to 85 million dollars per vessel.

" Polaris " may be in service this year and, together with the atomic submarine capable of operating in the most adverse arctic conditions if needed, will represent a very elusive and lethal deterrent weapon.[80]

Photographs (Figs. 19 and 20) were published last year of a Martin-built test vehicle A.L.B.M. called " Bold Orion." Like " Polaris," this is a two-stage solid rocket but it is much smaller—less than half the weight of the Navy weapon. Intense design studies by a score of companies were completed during 1959, resulting in Douglas receiving a contract for the missile XGAM-87A to Weapon System 138A (" Skybolt "). A demonstration of guidance accuracy was provided by the firing of a Martin " Bold Orion " on October 13, close to the orbital path of the satellite " Explorer VI " ("Paddle-wheel "). The miss distance has been quoted to be of the order of 4 miles with the satellite at a height of about 150 miles.[81] The second stage was the " Meteor " solid rocket made by Grand Central Rocket Company, for " Vanguard " third stage. No performance has been officially quoted, but press reports speak[82] of a range of 1000 miles when launched at an angle of 45 deg. in a toss manœuvre from typical high subsonic speed jet bombers.

Large Surface-Air Interceptor Missiles : " *Bomarc.*"—The latest version of this rocket-boosted, ramjet cruising interceptor (IM-99B) was first fired in April, 1959.[83] Its Thiokol solid booster rocket is in the body, control being provided by a jetavator annular vane in the nozzle. This deflects the exhaust jet, giving large lateral moments which are particularly desirable during the early phases of flight before aerodynamic control is established by the wing tip ailerons and tail surfaces.





Figs. 19 and 20—The two-stage Martin rocket that was directed into proximity with " Explorer " IV is seen before and after installation on a B-47 " Stratojet." Notice that during the burning of the first stage it flies as a canard. This experiment was conducted to study the feasibility of the air-launched ballistic missile

" *Nike Zeus.*"—Several important details of this anti-missile missile were published in 1959. It has evolved from the " Nike Hercules " configuration as a large, two-stage, very narrow delta cruciform rocket vehicle. The first stage solid booster gives a thrust of 450,000 lb and is 20ft long. The winged second stage is about 30ft long. The nose section separates and is capable of controlled flight in the later stages of interception. It is reported to be intended to reach the " kill " height of about 250 miles in two minutes. A test vehicle was fired at White Sands during the year, and eventual interception tests from Kwajalein in the Pacific have been scheduled for 1962. Douglas, Western Electric and Bell Telephone Laboratories are main contractors, and the project is directed by the Army Rocket and Guided Missile Agency at Huntsville. Technical interest in this system centres particularly on such factors as detection of warheads from decoys and whether more sophisticated bombardment weapons can outstrip the capability of the interceptors, the scale of deployment over large continental areas, and the large cost of a nation-wide system.[84] Work on " Nike Zeus " would contribute to the satellite interception problem.

Space Vehicle Boosters.—Progress has been made in two ways : first, in adapting military ballistic missiles to take special upper stages for space flight ; and secondly, in the announced programme for advanced space boosters quite different from military hardware as such.

The American rockets used during 1959 for satellite launchings or space probes, with the exception of " Vanguard," were all composed by piecing together modified missiles. The rockets employed in addition to " Vanguard " itself were the " Thor-Hustler " (" Thor " I.R.B.M. first stage) ; " Juno 2 " (" Jupiter " I.R.B.M. plus modified " Sergeants ") ; and " Thor-Able " (" Thor," modified " Vanguard "; and " Vanguard " third stage).

The " Atlas-Able " was developed during the year, and was used for the unsuccessful " Pioneer 5 " experiment, as noted in the table of satellites and space probes.

During 1959, Lockheeds introduced the " Agena "[85] as a versatile upper stage for space experiments. It has evolved from the " Discoverer " top stage and when used with " Atlas " as first stage is expected to have the following performance :

3000 lb satellite in 300 mile orbit ; 720 lb deep space probe ; 300 lb soft moon landing.

The present " Agena " (for " Discoverer ") is 19ft long and 5ft in diameter, weighs 8500 lb gross and 1700 lb empty, with a payload of 600 lb, and a motor thrust of 15,000 lb. When used with " Atlas " it will be lengthened and will develop more thrust from its Bell Aircraft " Hustler " rocket motor.

1960 should bring achievements by the " Thor-Delta," which is a modified " Thor-Able," using the radio-inertial guidance system at present employed with " Titan." The N.A.S.A. hopes to place up to 500 lb payloads in circular orbits with the " Thor-Delta."

A striking new family of four vehicles, to be designed for spaceflight and to employ various combinations of the seven basic engines already noted under Propulsion, was described by the N.A.S.A. in 1959. The first of these, " Vega," has recently been cancelled,[86] for it was intended merely for interim use until " Centaur " could be developed ; delays have made it evident that both " Vega " and " Centaur " would have become operational within about a year's time.

With " Centaur," " Saturn " and " Nova " the N.A.S.A. evidently intend to move into performance areas which far exceed ballistic missile requirements and existing satellite booster capabilities, although modified I.C.B.Ms. will be used for certain stages. The N.A.S.A. policy is to use the seven basic engines, now being developed, as much as possible in order to keep costs to a minimum. Nevertheless, the booster vehicle programme has been estimated to cost some two billion dollars over the next ten years.

" Centaur " will have a modified " Atlas " first stage. The second stage will use two 15,000 lb thrust liquid hydrogen liquid oxygen engines of the type recently developed by Pratt and Whitney. It will also be possible to employ a third stage, and when this is required the 6000 lb thrust storable propellant engine developed by the Jet Propulsion Laboratory will be used. " Centaur " will be the first vehicle to use hydrogen, and the high energy second stage should bring very promising payload capabilities. The rocket will be about 110ft high and 16ft maximum diameter.

" Saturn " is the N.A.S.A. very large space booster which will give a performance at least an order of magnitude greater than that possible from I.C.B.M.-class vehicles with added stages. It has a high priority in the quest to give the U.S. competitively large boosters for satellite applications, manned spaceflight and lunar landings. Its size is hard to visualise—it is 200ft high, 22ft in diameter and will weigh 580 tons at launch. Pertinent design and performance details were published in mid-1959[87]—based on " Titan " stages and kerosene-lox motors. Significant revisions to include more liquid hydrogen rockets were announced at the end of the year.[88] The differences are indicated briefly in the table below :

Stage	Length ft	Early proposals (mid 1959)	Later proposals (end 1959)
1st	75	Eight H-1 Rocketdyne kerosene-lox engines, 1,300,000 lb thrust	As before
2nd	60	" Titan " first stage (lox-kerosene), 360,000 lb thrust	Cluster of four 150,000 lb hydrogen engines
3rd	45 ?	" Centaur " lox-liquid hydrogen 30,000 lb thrust...	Two 150,000 lb hydrogen engines
4th	20 ?	600 lb storable rocket of J.P.L. (?)	Four P. and W. 15,000 lb hydrogen engines
5th	?	—	" Centaur "-hydrogen engines, 2XLR 115=30,000 lb thrust

Although the new larger hydrogen engines may take three years to build, the extra performance may well enable " Saturn " to accomplish tasks hitherto expected to call for the even greater (and later) " Nova." Exact payload performance has not been quoted for the revised design, but may be in the region of 50,000 lb, for example, in an earth orbit.

Management[89] of the project rests with the Army Ballistic Missile Agency at Huntsville (N.A.S.A.). under the director of the Development Operations Division, Dr. Wernher von Braun.

The availability of boosters off the military programme to meet the space timetable caused some concern in 1959[90] and further technical discussions have taken place on recoverable boosters.[91] Recovery scheme studies for " Saturn " are on contract.

" Nova " is the largest vehicle in the N.A.S.A. current programme, capable of orbiting very large manned earth satellites and of manned lunar flight. The first stage will be a cluster of four 1,500,000 lb thrust units, single-chamber versions being devel-

oped by Rocketdyne. Second stage will use a single 1,500,000 lb unit. Third stage will be roughly I.C.B.M. size but will use liquid hydrogen. Fourth and fifth stages would use high energy storable propellant engines now forming part of the booster development project. The five-stage version would be more than 250ft high, and a seven-stage vehicle is also contemplated. The mission capability is the transport of several men to and from the moon. Alternatively, an earth satellite of about 150,000 lb could be placed in a close orbit.

Small Research Boosters.—Although the big boosters get the limelight, a great deal of continuous high altitude atmospheric research will be carried out for several years with smaller solid rocket vehicles designed primarily with economy in mind. There are three such vehicles in the U.S.A., and " Skylark " in U.K. N.A.S.A. project " Scout " (" the poor man's rocket ") has four solid rocket stages for placing instruments in orbit or probing outer space to a distance of about 5000 miles.

The stages are :

First—modified " Polaris " motor—by Aerojet-General.

Second—an improved " Sergeant " engine by Thiokol.

Third—larger version of " Vanguard " third stage.

Fourth—modified version of the existing Alleghany " Vanguard " engine.

" Scout " rockets will be used in both the British and Canadian space research programmes, and as part of N.A.S.A.'s N.E.R.V. (Nuclear Emulsion Recovery Vehicles) programme to study the lower Van Allen radiation belt. In November it was announced that the first production " Scout " had been made by the contractors, Chance Vought.[92]

In December the first photograph was shown of the Jaguar[93] rocket designed to reach heights of 600 miles for natural radiation measurements. It has three solid rocket stages and is air launched from a Martin B-57 (" Canberra "). The double advantage of air launching, from the research point of view, is reduction of rocket weight and the ability to fly away from launching sites into regions of immediate local interest, e.g. near magnetic disturbances or auroræ.

The third example is the N.A.S.A. five-stage " Jason "[94] developed from a hypersonic test vehicle already in use for several years. This was used as part of the " Argus " experiment to monitor the radiations from high altitude atomic explosions.

British Rockets

The De Havilland " Blue Streak "* long-range ballistic missile is 81ft in height and has a diameter of 10ft. The launch weight is about 175,000 lb, the launch thrust is 300,000 lb, and the range and re-entry speed are said to be nearly 3000 miles and about 13,000 m.p.h. respectively. It would appear that the thrust is more than is needed at present ; an excess may have been allowed for future extensions of performance, and this excess would be useful if " Blue Streak " assumed a space role. The twin liquid rocket engines were developed and manufactured by Rolls-Royce, Ltd., under licence from North American Aviation Rocketdyne Division, and the exact nature of the propellant has not been revealed, although it is known that liquid oxygen will be the oxidiser.

Bristol-Siddeley Engines have in recent months developed small vernier rockets, using H.T.P. and kerosene and delivering about 500 lb thrust each, for control assistance during the boost phase and for final trajectory corrections after burn-out of the main engines. The missile is designed for launching from underground silos, and surface test emplacements at Woomera are understood to be nearly completed. The potentialities of "Blue Streak" as a booster for space vehicles were described at the Commonwealth Spaceflight Symposium in August by G. K. L. Pardoe.[95] With either a single solid rocket or " Black Knight " as second stage, a payload of about 1000 lb could be placed in a 300 mile orbit. Using a specially modified " Black Knight " stage, about 2000 lb could be placed in a 300 mile orbit. The addition of a third stage would make possible the lunar landing of a small instrument package.

The Saunders-Roe " Black Knight " ballistic test vehicle had made five successful flights up to December, 1959, making a noteworthy reliability record. Overall design, research and development authority is vested in the Royal Aircraft Establishment, while Saunders-Roe, Ltd., are the main contractors. The four " Gamma " liquid motors for the first stage, using H.T.P. and kerosene, are designed and produced by Bristol-Siddeley Engines. Three alternative configurations now exist : a single-stage re-entry vehicle ; the same vehicle adapted to carry a payload of equipment under test ; and a two-stage vehicle with a solid second stage for very high re-entry speeds.

The second " Black Knight," launched at Woomera early in 1959, reached an altitude of 350 miles, 50 miles higher than the first. The others launched during the year maintained a similar performance. The single-stage vehicle is 35ft long and 3ft in diameter, and has a sea-level thrust of 16,400 lb. With the addition of the new solid second stage, altitudes of about 1500 miles are expected. Instruments for the telemetry of ascent and re-entry conditions are carried, and the vehicle has been used for the assessment of various nose-cones and for tests on components of the " Blue Streak " guidance system.

Rockets flying within the atmosphere were discussed in the article devoted to " Aeronautics."[96]

Soviet Rockets

Very little technical data have been revealed by the U.S.S.R. During 1959 more details were given of high altitude sounding rockets and their experimental results, but virtually nothing about the big space boosters. An article published in December[97] was compiled from the study of hundreds of books and periodicals in the Russian language and gives a survey of past and existing rockets and of current trends. But the security shroud over Russian efforts makes certainty very difficult. This review made the following observations. The Russians have further developed the " V–2 " system. A vehicle, the " CH–10," was used to launch " Luniks " 1, 2 and 3. " CH–10 " is in three stages, plus two solid boosters of 88,000 lb thrust each. The first stage is powered by two R–14 engines, burning liquid oxygen and kerosene, each having a thrust of about 242,000 lb, thus giving (with the boosts) a total first stage thrust of 660,000 lb. The second stage also uses two R–14 engines ; while the third stage, designated " R–10," is an improved version of the " V–2 " and uses watered alcohol and liquid oxygen. In order to achieve the degree of accuracy displayed by " Luniks " 2 and 3, parallel advances in guidance and control systems must have been made.

Space Flights Achieved in 1959

Table II presents some information on satellite and space probe activity during 1959. Upper atmosphere research rockets have been excluded ; there has been a good deal of activity in this field, but upper atmosphere and space research have already been well covered by previous work.[98]

The American highlights of the year were undoubtedly the live recovery of the monkeys, " Able " and " Baker," after a 300 mile flight into space on May 28, and the placing in orbit of the " paddlewheel " satellite (" Explorer " 6), the most sophisticated satellite yet launched, on August 7. As will be seen from the table, " Explorer " 6 covers various experiments, including the gathering of cloud cover data. Two purely meteorological satellites, " Vanguards " 2 and 4, were launched—only " Vanguard " 2 reached orbit and the oscillating motion it developed made data interpretation difficult. " Explorer " 6 suffered a misfortune also, for one of its " paddles," containing solar cells, failed to extend properly, and the power for data transmission was limited. Eight other American satellites were placed in orbit in 1959, and " Pioneer " 4 made a " near miss " of the moon—not close enough, unfortunately, to conduct its photo-electric sensor experiment—and went into a solar orbit. " Pioneer " 4 provided excellent radiation data and was tracked for a record distance of 407,000 miles.

The Russians had earlier (January) made a near miss of the moon with " Lunik " 1, which went into solar orbit. The most spectacular Russian achievements were the impacting of " Lunik " 2 on the moon in September, and the photographing of the moon's hidden side with " Lunik " 3 in October : 1959 satellite honours should, therefore, go to the U.S.A., and lunar probe honours to the U.S.S.R.

Future Space Flights Announced During 1959

During 1959 the Americans announced new satellite programmes for communication (" Notus "), navigation (" Transit ") and meteorological (" Tiros ") purposes.

" Notus "—Greek for " south wind "—was initiated by the U.S. Department of Defence. It is the Advanced Research Project Agency's code name for the total communication satellite effort planned up to 1965, and includes satellites in stationary equatorial orbits. One element of the programme is " Task Steer," placed with General Electric and the Bendix Aviation Corporation at the end of September. " Task Steer " will be a polar communications satellite, providing instantaneous relaying of radio signals between widely separated aircraft or ground stations, of especial value to stations in high latitudes where radio communications are at present unreliable, and will probably be placed in an orbit of several thousand miles by a " Centaur " rocket. Also associated with the communications satellite programme is " Project Courier," the first " Courier " being planned for launch during 1960 into a 500 mile orbit, weighing about 500 lb and capable of handling up to forty incoming and outgoing teletype messages simultaneously. " Project Echo " is a feasibility study for passive communications relay. Three inflatable 100ft diameter reflecting spheres,[99] weighing about 150 lb and made of thin Mylar coated with aluminium, will be placed into 1000 mile orbits. The experiment will be conducted between the Jet Propulsion Laboratory at Goldstone and a radio telescope in

*Since this article was prepared for publication, it has been announced that "Blue Streak" no longer has any military status.

Table II — *Space Vehicles Launched During* 1959

Name	Carrier rocket	Launch date and lifetime	Main purposes	Orbit			
				Perigee height, miles	Apogee height, miles	Nodal period (minutes)	Inclination to equator (deg.)
"Mechta ("Lunik" 1).*—Sphere, 800 lb. Aluminium-magnesium alloy shell. Passed within 3125–4375 miles of the moon	Modified Russian I.C.B.M.?. 3–4 stages. Last stage 20ft long, 10ft in diameter	January 2. Believed to be in orbit around sun on cycle of 15 months	Internal measurements: temperature and pressure. External: components of interplanetary gas; solar radiation; micro-meteorites; cosmic radiation; magnetic fields of earth and moon	91·2 million (perihelion)	123·1 million (aphelion)	450 days	—
				Artificial satellite of the sun			
"Vanguard 2."* Sphere, 20in in diameter. 20·74 lb. Magnesium, silicon monoxide-coated, highly polished surface (1st weather satellite)	U.S. Navy "Vanguard." 3 stages. Last stage 5ft long, 20in diameter—still in orbit near satellite. Overall length 72ft. Overall launch weight 22,600 lb	February 17. Estimated 10 years or more.	Cloud cover data for 2 weeks (crude images from 2 photocells). A wobbling motion developed by the satellite made data interpretation difficult	347	2064	125·85	32·88
"Discoverer 1." Cone-cylinder, 18·8ft long, 5ft in diameter. 1300 lb (245 lb of instruments)	U.S.A.F. "Thor-Hustler." 2 stages. Overall length 78·2ft. Overall launch weight 108,500 lb approx.	February 28 to March 5	Checks on propulsion, guidance, staging and communications. First launch into a polar orbit. Radio failed and orbit was not stabilised	99	605	95·9	3 deg. off earth N.–S. axis
"Pioneer IV"* (space probe). Cone, 20in long by 9in diameter. 13·4 lb. Gold-washed fibre-glass shell. Passed within 37,300 miles of the moon, was tracked for 82 hours to a distance from earth of 407,000 miles	U.S. Army "Juno 2." 4 stages: 1—"Jupiter," I.R.B.M., modified; others were scaled-down "Sergeants." Overall length 76ft. Overall launch weight 121,000 lb	March 3. In orbit around sun	To measure radiation in space, to test a photo-electric sensor (for triggering cameras in future moon probes) if close enough to moon. Yielded excellent radiation data but did not pass near enough to moon to test sensor	91·7 million (perihelion)	107·9 million (aphelion)	406·95	—
				Artificial satellite of the sun			
"Vanguard" 3A and 3B.—"3A": Sphere, 13in in diameter, with cylindrical extension 17·5in long and 2·5in in diameter. Fibre-glass and phenolic resins. "3B": Inflatable sphere (no instruments,) 30in in diameter, laminated aluminium foil and plastic sheet. Total weight ("A" and "B") 23·3 lb	U.S. Navy "Vanguard"—same as "Vanguard 2"	April 13—failed.	"3A"—mapping of earth magnetic field. "3B"—optical tracking, drag studies in outer atmosphere. 2nd stage of carrier rocket failed to function properly	Failed to reach orbit			
"Discoverer 2." — Cone - cylinder, 19·2ft long, 5ft in diameter, 1610 lb (245 lb of instruments)	U.S.A.F. "Thor-Hustler"—similar to "Discoverer 1"	April 13–April 26	Recovery of 195 lb hemispherical capsule, using small retro-rocket to aid re-entry; maintenance within capsule of suitable temperature and sufficient oxygen to sustain life; measurements of radiation in space. Capsule was ejected but not recovered	142	220	90·5	0·2 deg. of earth N.–S. axis
"Discoverer 3."— Cone - cylinder, 19·2ft long, 5ft in diameter, 1600 lb (245 lb of instruments)	U.S.A.F. "Thor-Hustler"—similar to "Discoverer 1"	June 3—failed	Biological tests—4 mice placed in recoverable capsule. 2nd stage of carrier rocket failed	Failed to reach orbit			
"Vanguard 4."—Sphere, 20in in diameter. Magnesium shell, silicon monoxide coated, highly polished, 21·5 lb	U.S. Navy "Vanguard"—as for "Vanguard 2"	June 22—failed	Cloud cover data (2 infra-red photocells). 2nd stage failed	Failed to reach orbit			
"Discoverer 4." — Cone - cylinder, 19·2ft long, 5ft in diameter, 1600 lb (245 lb of instruments)	U.S.A.F. "Thor-Hustler"—similar to "Discoverer 1"	June 25—failed	Capsule separation and recovery tests. 2nd stage failed	Failed to reach orbit			
"Explorer 6" (U.S. Army).—Toroidal, 30in by 30in in diameter, 91·5 lb. (N.B.—N.A.S.A. decided that in future names would only be given to vehicles which reached orbit or space)	U.S. Army "Juno 2"—as for "Pioneer 4"	July 16—failed	Seven experiments: solar X-rays, Lyman-Alpha radiation, cosmic radiation, heavy nuclei, micro-meteorites, radiation and heat balance. Control failure at take-off	Failed at launch			
"Explorer 6"* (U.S.A.F.) — Spheroid, 26in in diameter, 29in deep, with four 20in square vane extensions. Aluminium skin, 142 lb. ("Paddle-wheel" satellite: vanes consist of 8000 tiny solar cells; most sophisticated satellite to date)	U.S.A.F. "Thor-Able."—3 stages: 1—"Thor I.R.B.M.; 2—modified "Vanguard"; 3—"Vanguard." There is also a solid "kicker" rocket on the satellite, 14in long (not yet used—may be used later to raise perigee altitude). Overall length 90ft. Overall launch weight over 105,000 lb	August 7. Estimated 1 year	Fifteen experiments — these included: mapping earth magnetic field, studies of behaviour o-radio waves in ionosphere, microf meteorites, cloud cover, tests of "deep space" communication equipment	157	26,380	750	48

Table continued opposite

New Jersey. The anticipated radio reflectivity of "Echo" spheres is 98 per cent for frequencies up to 4000 Mc/s. The "Thor-Delta" rocket will be used for each launching.

"Project Tiros," initiated in mid-1958 by A.R.P.A. and later taken over by N.A.S.A., is more sophisticated than the previous two weather observation experiments of "Vanguard" 2 and "Explorer" 6. "Tiros" satellites are the first to be specially designed for meteorological observations. The previous experiments involved only crude arrays of photocells. Two television cameras of a type being developed by R.C.A. will be incorporated in "Tiros," which will be spun and stabilised to ensure fixed orientation with respect to the stars. Later versions may be attitude-stabilised to permit constant direction of the cameras towards Earth. The first satellite launching was with a "Thor-Able" rocket and achieved a short working life. A near-circular orbit of between 350 and 400 miles in height is planned and the date of November, 1960, has already been suggested for a second launching, this time with a "Thor-Delta" rocket. "Tiros" will set immense problems of ground data processing, aimed at analysing and distributing information in time to be of service to world meteorological bureaux.

"Transit" 1, also called the first navigation satellite, failed to orbit in September when the third stage of the "Thor-Able" rocket did not ignite. The satellite carried special transmitters to enable ground stations to determine the ionospheric refraction of radio waves, information which is needed before satellites can be used for navigation purposes.

GROUND SUPPORT EQUIPMENT

Having discussed rocket engines, rocket-propelled vehicles and their accomplishments, some reference should be made to the very many other important engineering operations that enter into the whole picture.[100] Ground support equipment (G.S.E.) is an American term intended to include launchers, transporters and test gear. It is not generally known that most of ground-launched ballistic missile systems costs go into the G.S.E.[101] A typical example is afforded by the costs of a "hardened" "Titan" squadron site. Each launching area consists of a main pit 163ft deep and 40ft in diameter, surrounded by other pits for propellant and other storage, and for equipment and personnel. The subsidiary pits will be separated from the main missile pit by about 40ft of earth. Air-conditioned tunnels will interconnect the pits, which will be so equipped that the launch unit will function independently. Nine of such units will normally make up one "Titan" squadron. There are known to be at least five squadrons at which construction of the silos is in progress.

The following figures give some idea of the relative operational costs of the component elements of a system such as "Titan":

Items per squadron	Approximate cost, million dollars
Base construction—digging nine silos and laying reinforced concrete	42
Nine "Titans" at over 2,000,000 dollars each	20
Radio-inertial guidance equipment	14
Propellant loading equipment	9
Launchers	19
Automatic check-out system	4
Communications and firing control systems	1
Transport and handling equipment	0·35
Total per squadron	109·35

The exact nature and cost vary widely from missile to missile. The "Titan" costs are probably about the most expensive ever likely to be met. G.S.E. costs associated with air-launched bombardment missiles

Name	Carrier rocket	Launch date and lifetime	Main purposes	Orbit			
				Perigee height, miles	Apogee height, miles	Nodal period (minutes)	Inclination to equator (deg.)
"Discoverer 5." — Cone - cylinder, 19ft long, 5ft in diameter (capsule 27in long, 33in in diameter), 1700 lb (including 300 lb capsule)	U.S.A.F. "Thor-Hustler"—similar to "Discoverer 1," except for use of more powerful fuel in 1st stage	August 13–September 28	Recovery of capsule ejected from orbit. Capsule ejected but not recovered, possibly owing to battery failure	136	450	94	Polar orbit
"Discoverer 6." — Cone - cylinder, 19ft long, 5ft in diameter, 1700 lb (300 lb instrument capsule)	U.S.A.F. "Thor-Hustler"—as for "Discoverer 5"	August 19–October 20	Recovery of capsule ejected from orbit. Capsule ejected but not recovered, again possibly due to battery failure preventing signals from the falling capsule	138	537	95·27	84
"Lunik 2."—Sphere (860 lb). Burnt-out final stage impacted on moon shortly after the instrument package	—	September 12 – September 13	To impact on moon, after measuring interplanetary gas, radiation intensity and micrometeorites; also investigation which showed that moon lacks a magnetic field	—	—	—	—
"Transit 1."—265 lb "navigation satellite"	U.S.A.F. "Thor-Able"	September 17—failed	Radio communication satellite designed to investigate feasibility of supplying navigational information to ships and aircraft. Final stage did not ignite	Failed to orbit			
"Vanguard 3."*—Sphere with small diameter cylinder extension, 20in in diameter, made of magnesium and fibre-glass. 100 lb (50 lb instruments) (last in the "Vanguard" programme)	U.S. Navy "Vanguard"	September 18. Estimated 70 years	Detection of solar X-rays; measurements of earth magnetic field; micrometeorites; internal and external temperatures	319	2329	129·99	33·3
"Lunik 3."*—614 lb (orbits earth and moon). Short cylinder with hemispherical ends	—	October 4. Estimated 10 years	To take photographs of the far side of the moon, and to transmit them to earth	30,000	291,000	22,300	75
"Explorer 7."*—Double cone, 30in long and 30in in diameter, 91¼ lb (last satellite launching connected with I.G.Y., which officially ended December 31, 1958)	U.S. Army "Juno 2"—similar to that used for "Pioneer 4"	October 13. Estimated 20 years	Measurements of earth radiation balance, Lyman-Alpha and soft X-radiation, heavy primary cosmic rays, micrometeorites, solar cell functioning and internal temperatures	330	710	101·30	50
"Discoverer 7."—300 lb instrument capsule	U.S.A.F. "Thor-Hustler"	November 7	Ejection and recovery of instrument capsule. Should have been ejected on 17th revolution—failed to eject; also developed instability in orbit	104	550	95	—
"Discoverer 8."*—300 lb instrument capsule	U.S.A.F. "Thor-Hustler"	November 20. Estimated life—short	Ejection and recovery of instrument capsule. Orbit more eccentric than scheduled. Capsule ejected after 15 orbits instead of 17, and not recovered	116	913	103	—
"Pioneer 5" (lunar probe).—372 lb. Since all existing rockets appear to be required for other purposes, experiment not likely to be repeated for some time. Novel features were: 2 mid-course guidance rockets under radio command; internal temperature control at about 70 deg. Fah., using 50 small "propellers" on the probe's surface which automatically turned to provide light and shade	U.S.A.F. "Atlas-Able" (1st stage "Atlas"; 2nd—an Aerojet-General engine; 3rd—"Vanguard" solid 3rd stage)	November 26—failed	Was to have gone into a "captured" orbit of the moon. Carried a 2 lb electronic scanner to take pictures of surface. Also equipped for measurements of radiation, magnetic fields, micrometeorites, solar flare emission and interplanetary gas. Second stage failed	Failed			

* Vehicles marked with an asterisk (*) were still in orbit in December, 1959.

The following, launched before 1959, were also still in orbit in December.

	Launch date	Estimated life
"Explorer 1"	February 1, 1958	4 years
"Vanguard 1" (plus carrier rocket orbiting nearby)	March 17, 1958. Now suffering electrostatic drag from the potential of several thousand volts picked up, apparently, in its travel	100 years. Still yielding significant data
"Sputnik 3"	May 15, 1958	21 months was originally estimated

used with existing aircraft are very much less.[102] Typically, ground launched ballistic missiles spend 70 per cent of the overall system cost on G.S.E.; for air-launched missiles it is closer to 20 per cent.

Much steel, concrete, pipes and electrical wiring goes into the control room[103] and launching towers at the ranges (Fig. 21). For smaller vehicles such as "Scout," much is scaled down proportionally (Fig. 22). Testing very large thrust rocket engines requires special thrust measuring rigs, complex instrumentation, vast quantities of water to cool the surfaces on to which the exhaust blasts, and storage and pumping of fabulous volumes of cryogenic or toxic propellants (Fig. 25).

The introduction during 1959 of liquid hydrogen rocket motors has focussed attention on the production, transport and storage of this very low boiling point liquid. Union Carbide opened a liquid hydrogen plant at Tonawanda (New York) in November, 1959 (Fig. 27) to produce 25,000 litres (1·95 tons) per month. Impurities are less than two parts in 1,000,000, and the more stable form (para hydrogen) has been concentrated to 95 per cent (cf. about 25 per cent as first liquefied). Plans have also been made to build a larger plant at Torrance on the West Coast to provide N.A.S.A. with, at least, 3,300,000 lb hydrogen per annum, primarily for space vehicle rockets. Very large tankers (Fig. 28) are now in regular use for transporting liquid hydrogen—the Linde Company make several, including a 7,800-gallon road semi-trailer 40ft long and a 26,000-gallon railway tanker 63ft long and 11ft 6in diameter.[104] Typical insulations for these tankers are Perlite or Linde SI-4 which possesses thermal resistivity thirty-six times better than available eight years ago.[105] The railway trailer has 15in thick insulation and could be designed to lose only 10 per cent of the tank contents per year.

Experimental results have been published of fire and explosion hazards incurred in running liquid hydrogen rockets in test stands.[106] When accidentally mixed with air under unconfined conditions hydrogen does not detonate and radiation effects of any fire are less than with more conventional fuels. The well-known danger of ignition of a hydrogen vapour cloud, which was the doom of the airship, will be present and test plants, pipes and tanks must be carefully designed to minimise this hazard.

During 1959 Bristol Siddeley produced a special mobile drying-out plant for hydrogen peroxide rocket systems (Fig. 26). Air is supplied at 8 lb per square inch and 80 deg. Cent. to evaporate any residual H.T.P. which might otherwise cause electrolytic corrosion of metal parts. The system is claimed to have advantages over the usual technique of flushing with demineralised water.

MAN IN SPACE

American efforts are concentrated on two immediate projects—the X-15 research aeroplane and the "Mercury" ballistic capsule. These have been so well publicised[107, 108] that little description is needed here.

The X-15 is a piloted vehicle designed to explore the flight regime of the fringes of atmosphere and space, and to investigate re-entry problems. The results will be used in the design of future high-speed, high-

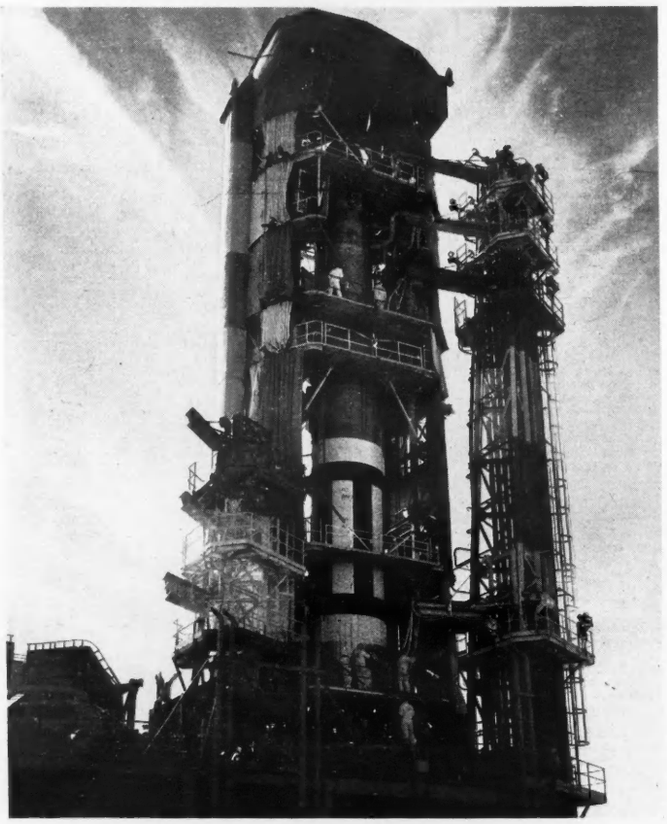


Fig. 21—An early " Titan " is prepared for launching at Cape Canaveral

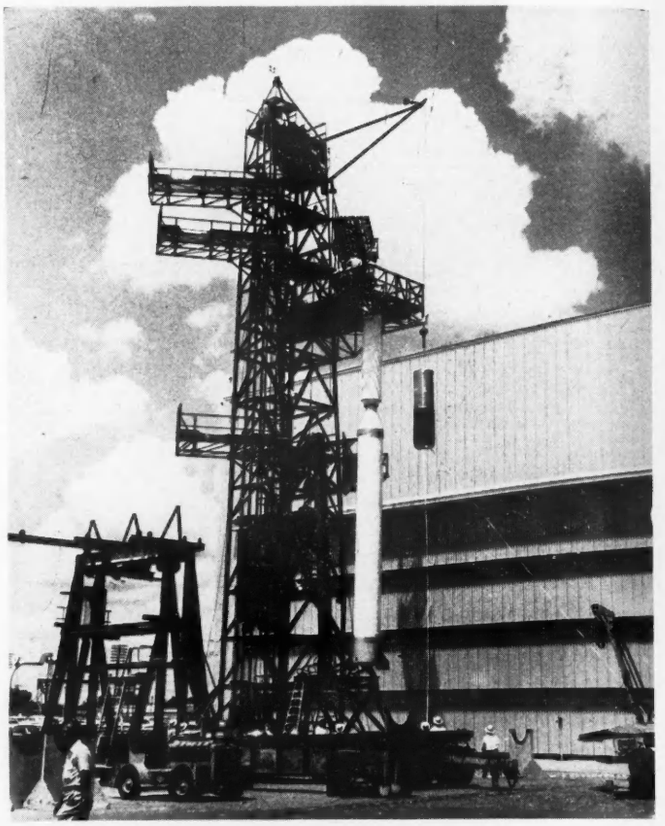


Fig. 22—Third stage of Chance Vought " Scout " being hoisted into place

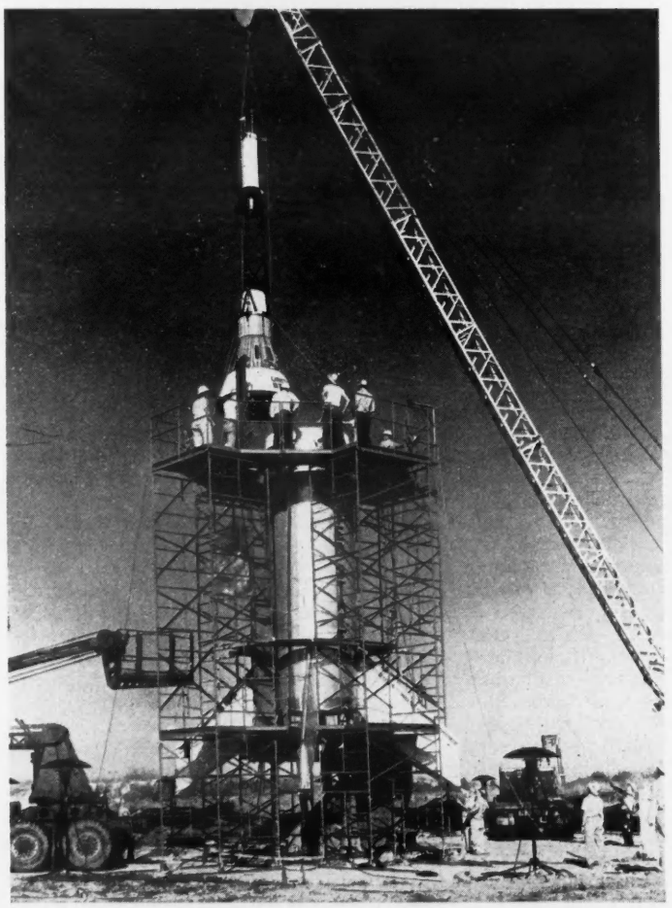
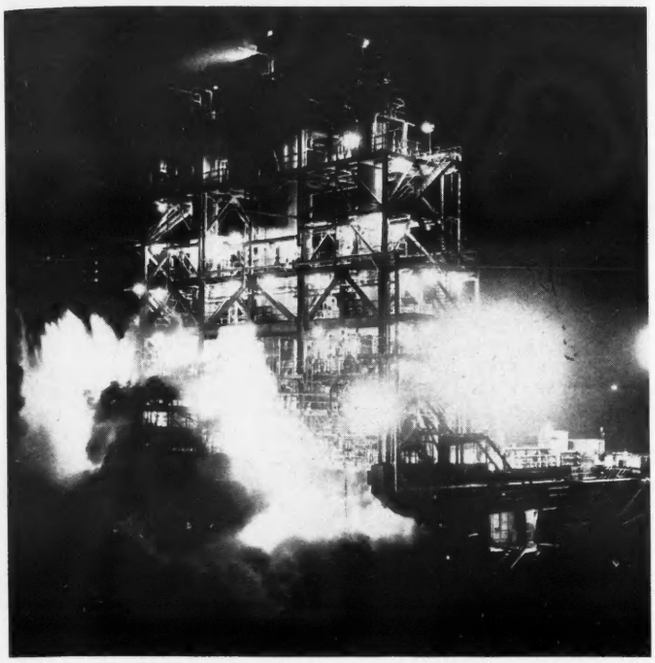


Fig. 23 (Left)—A Project " Mercury " capsule being mated to a booster vehicle at Wallops Island before launching to altitudes above 40 miles to prove performance of the escape tower (attached to top of capsule) and of the recovery parachutes. Eight solid-fuel motors power the " Little Joe " launcher. Fig. 24 (Right)—A Project " Mercury " test capsule is shown in place on an " Atlas " missile before launching at Cape Canaveral. " Big Joe " weighs a ton, measures 9ft 6in in length and tapers from a diameter of 6ft at the base to 20in at the nose



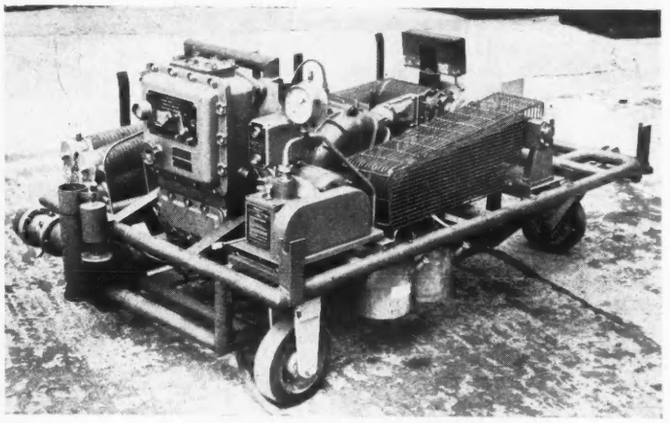


Fig. 25 (Left)—The Aerojet engines of a " Titan " under test

Fig. 26 (Above)—A Bristol Siddeley equipment for drying out hydrogen peroxide engines ; it has a Wade blower supplying air at 80 deg. Cent. and an Edwards " Speedivac " pump installed

altitude air vehicles and manned space vehicles. The aircraft is carried under the right wing of a B-52, and a typical flight plan is 458 miles in track and up to 100 miles high. Jet controls will be used while in space. Speeds of more than 3600 m.p.h. and altitudes greater than 100 miles are expected to be reached in X-15 flights. Propulsion is by a Thiokol single-chamber rocket engine burning liquid anhydrous ammonia and liquid oxygen, with a maximum thrust of over 50,000 lb and variable thrust capability. Fuel is consumed at the rate of more than 10,000 lb per minute in this engine, as compared with a typical consumption of an afterburning jet engine of 500 lb per minute. The total free-flight time of the X-15 will be about twenty-five minutes, which will include only short periods of flight in space—the aircraft will not, of course, be capable of orbiting in its present form. With a rocket launcher, however, it might.

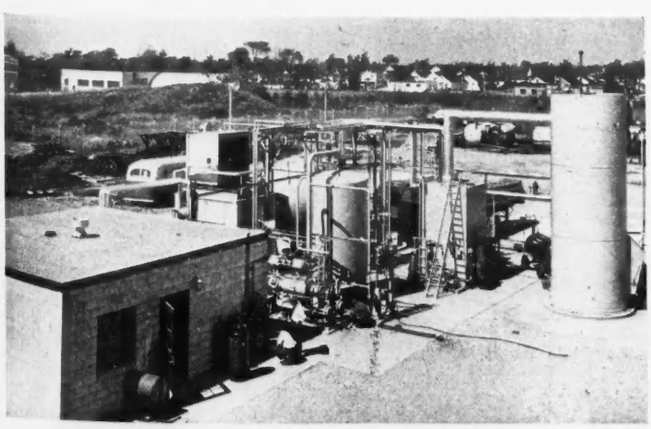
On March 10, 1959, the X-15 made its first " captive " flight attached to a B-52. This was followed by three more carriage trials, then a free gliding flight in June. Powered test flights were made in September and October, but during the third, on November 5, an engine explosion necessitated an emergency landing which was accomplished without injury to the pilot, but the aeroplane broke its fuselage. Successful powered flights have since been made.

The object of " Project Mercury " is to fire a man into space in a capsule and achieve successful recovery after re-entry. A group of seven possible astronauts was selected and commenced training early in 1959, and each member will be required to make a test trip in a modified " Redstone " missile. The re-entry speed will be similar to that of a ballistic missile nose-cone and the emphasis is, therefore, on maintaining habitable internal temperatures in the capsule. In January, McDonnell Aircraft were awarded the " Mercury " capsule contract, which calls for twelve capsules, twelve ablation shields (six of beryllium), six escape systems, and six retro-rocket systems. On September 9, a test capsule was fired over 1500 miles and recovered from the sea after reaching a speed of 14,000 m.p.h. and an altitude of 100 miles (Fig. 23). It is reported that internal temperatures during re-entry did not exceed 40 deg. Cent. Faster and longer flights will be made with the " Atlas " booster (Fig. 24). The project is accounting for about 15 per cent of the total N.A.S.A. budget for the current year, and is N.A.S.A.'s biggest single effort. Over a four-year period, the total cost is likely to be about 350 million dollars.

Manned rocket orbiting vehicles for the future are embraced by the " Dyna-Soar " programme, for which design study contracts were awarded to both Martin and Boeing as long ago as June, 1958, and the U.S.A.F. and the N.A.S.A. made a choice between the two concepts, details of which have not been revealed, in November, 1959. It has been reported that development contracts were awarded to Boeing for the boost-glide vehicle and to Martin for a modified " Titan " to be used as booster.

The purpose of " Dyna-Soar " is to explore the technical problems of flight in the sub-orbital flight regime, with emphasis on military problems. The first phase may be an unmanned glider of about 6000 lb weight, capable of sub-orbital flight at a maximum speed of 15,000 m.p.h. The second phase will probably be heavier, and be a manned vehicle requiring a two-stage booster instead of the " Titan." The phase 3 version will probably be about twice as heavy as the phase 2 vehicle, with a crew of two men, and would require a booster similar to the " Saturn " rocket to reach the requisite speed. Small turbo-jets will be used to assist landing of all three versions. The initial task, however, will doubtless be the test of a vehicle capable of making a conventional landing after limited flight at hypersonic speed. Goodyear have developed a wire tyre capable of withstanding *c*.1100 deg. Cent., which would be applicable to " Dyna-Soar."

The fully developed " Dyna-Soar " is expected to reach a speed of about 18,000



Figs. 27 and 28—Linde production plant and frameless-semi-trailer for liquid hydrogen

m.p.h. Progression in successive stages from the existing manned flight capability of X-15 to such a performance area will take time. The programme will also be costly ; first because " Dyna-Soar " will be rocket boosted from the ground and, secondly, owing to the expensive materials required, such as columbium, new refractory metals, and others. The heating problems will be far greater than those of X-15. About the middle of last year, the fate of " Dyna-Soar" seemed to be in the balance, for the prospect of high costs caused serious reconsideration by the U.S. Government. An alternative plan was to continue using air-launched research aircraft, based on X-15 pioneer work, until about Mach 12 was reached, and then commence a ground-launched " Dyna-Soar " programme. The " Dyna-Soar " 1960 budget suffered a severe cut in any event but has now proceeded beyond the stage of study.

Various shapes for manned hypersonic re-entry vehicles have been suggested in recent years, and it is not known whether " Dyna-Soar " will bear a resemblance to any shape already proposed in print. Towards the end of 1959, the N.A.S.A. revealed wind tunnel tests on re-entry gliders with inflatable wings, and a blunt dart shape is under consideration. These gliders would be capable of being enclosed uninflated in the nose-cone of the launching rocket, and wing loadings would be much smaller than with conventional structures.

No real Russian activity has been published except some space medicine experiments, and the continuing reports that they have a " Dyna-Soar " equivalent flying.

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The Royal Society Tercentenary Address

The Tercentenary of the Royal Society is being celebrated from July 18 to 26. At the formal opening ceremony in the Royal Albert Hall, London, on July 19, Sir Cyril Hinshelwood, the president, delivered his tercentenary address, extracts from which are reproduced below.

IN the year 1660 the Royal Society was founded. On the scale of cosmic evolution three centuries are as nothing but by the measure of human life they constitute an impressive span of history. Time in Newton's philosophy flowed uniformly on, but as the matrix of events significant to men it is not measured by the clock. For thousands of millions of years the present galactic cycle has continued, for a few thousand civilisation has been spreading round the Earth, and for a few hundred only there has been in progress that rapidly accelerating conquest of knowledge and power over nature, which has so largely created the world of to-day. The foundation of the Royal Society was symbolic of the conscious undertaking of this endeavour. In achievement the 300 years have exceeded all the infinite wastes of evolutionary time : by the scale of human events they are the fullest and longest in all existence.

* * *

What then have the men of science done in these three centuries ? How have they changed the course of history ? And these questions raise further ones. Is the change to accelerate further or come to a halt ? What does it mean to us ? It has brought us face to face with great dilemmas. Can the pursuit of knowledge any longer remain the concern of the few ? What then shall we do ?

After Newton's great synthesis, the law of universal gravitation, the conception of the stellar universe as an ordered mechanism, made probable by Copernicus, Galileo and Kepler, could no longer be in doubt, and grew in strength with the continuous elaboration of Laplace and his successors. Newtonian mechanics, wedded to the inventiveness of practical men, created modern engineering, and thereby made man largely the master of his environment, bringing him at length to the threshold of extra-terrestrial space. Twentieth century ideas, largely under the influence of Einstein, imparted a more abstract character to the fundamental notions of space and time, matter and energy. And by a strange paradox of nature it has been one of the most recondite and immaterial of adventures that has led directly to the release of nuclear energy and confronted mankind with one of the greatest practical problems it has ever faced.

The obscure and apparently unrelated curiosities of electricity and magnetism were unified at long last into the great body of electromagnetic doctrine. They provided the basis of electrical engineering and electronics by steps too intricate to trace in detail, but of which a crucial one surely was guided by the simple faith of Faraday that these two great natural forces were related. The patient genius with which he pursued his intuition was in its way prophetic, but he had little premonition of electric railways, of television or of automation.

The not infrequently disreputable operations of the alchemists grew into the science of chemistry. The atomic theory, fruitful after 2000 years, when experiment had replaced speculation, revealed at last the true secret of nature's elements and compounds, and guided the creation by man of compounds nature never knew. The stages in the development were complicated, the interrelations and inter-dependences of ideas and discoveries have been intricate beyond the possibility of any brief description.

Flight, speech and vision across the world, cures as by miracle from deadly illnesses, machines to which men delegate heavy toil, dextrous manipulation or mental exertion far beyond their own unaided powers, colours surpassing the rainbow in variety, all these things and more have come into being. The keys to unlock atomic energy have placed in man's hands undreamed-of powers which he may use for good or evil. The keys which unlock some of the secrets of human personality are slowly being cut, and men may soon be using them to do we know not what.

Is this not history ?

In the realm of ideas the story has been even stranger and more turbulent. The conception of the universe as a mechanism suggested a materialistic view of all existence, though not to Newton himself, and possibly less often to men of science than to onlookers unconscious of the real intention of scientific hypotheses. The time scales revealed by geology and biology appalled those who confused the literal truth of Genesis with the basis of religion and morality. And when the theory of evolution completed the outrage of man's expulsion from the centre of the universe by denying his special creation, resistance rose to its height. The opposition subsided only to be renewed at intervals against scientific doctrines, all of which have been of unquestioned utility in their own spheres, about the unconscious mind, about the chemical basis of genetics, the functioning of the brain and nervous system, or about the influence of hormones on personality.

Yet the men of science themselves, as far as can be judged, have numbered about the same proportion of religious believers as the generality of people. Indeed, an assurance that ultimate values of goodness and beauty can never be shaken by the pursuit of truth, wherever it may lead, is perhaps the sign of a robuster faith than is shown by recoil from every new and seemingly disturbing fact.

Meanwhile, in the natural course of discovery and interpretation, and uninfluenced either way by real or supposed philosophical or theological implications, scientific ideas evolved in a direction where they largely lost again their mechanical and materialistic semblance, and acquired a curiously abstract character. Indeed, some physical principles (though not, I think, adequately understood) have even been used in the present century in support of idealistic philosophies or to provide a doubtful support for the otherwise respectable doctrine of free will.

The quantum theory added a new element, that of discontinuity to the Newtonian conception of the world. Electrical particles,

the building blocks of matter, filling the universe with electromagnetic waves by their motions had offered for a time a synthesis of grand simplicity, powerful enough to create the whole technology of radio communications, and a major part of the electrical industry, yet itself destined for a revolutionary metamorphosis. Nature gradually disclosed that the invisible substratum of things, electrons, particles, and waves could no longer be described at all in terms applicable to the macroscopic world of the senses. Intuitive notions of space and time had been called in question by the theory of relativity ; the idea of a sub-atomic particle now became expressible only in terms of an abstract mathematical equation. Electrons themselves proved subject to the peculiar rule that only so many of them could be present in one system as were absolutely distinguishable by individual values of certain numbers which prescribe their state. Separate existence and experimental distinguishability were essentially linked. It is this almost metaphysical principle which accounts for the complete system of the chemical elements, with all their rich and varied detail. Particles appearing in nuclear disintegrations at high energies, mesons and the like, possessing the character of transience and decaying into others, present to-day an enigma which will probably not be solved until radically new principles have been discovered. The mysteries of the minute world of the atomic nucleus are found in magnified reflection in those of the stellar universe. How did the present cosmic era start ? Will it be renewed ? Is the so-called ultimate particle itself a cosmos of still smaller things ? Is the known universe contained within a particle belonging to some higher order ? Mystery and fascination have no end, the pursuit of knowledge has no limit. Three hundred years have witnessed the most colourful adventure ever undertaken. Is this too not history ?

And in the broader sense this story is that of the Royal Society, for its membership has known no restriction of race or nation. It has been proud to number a goodly proportion of the world's greatest men of science among its foreign members.

* * *

On this day of commemoration when the Royal Society lays the account of its stewardship before the world, it is meet to look not only backwards but forwards. What is to be the future of science ?

Extrapolation of history is impossible, perhaps in principle, certainly in practice. The equations of the present allow three possible types of solution for the future. Decline and catastrophe have been predicted on one ground or another, in spite of science, by overpopulation and starvation, or, through the agency of science, by wholesale destruction in nuclear warfare. Continued and accelerated progress have been confidently foretold, the curve sweeping upward faster and faster as each advance in knowledge multiplies the possibilities of further discovery, and as man more consciously assumes control of his own further evolution. Between lies the third and less spectacular solution, that the curve will level out or gently undulate. But the equations are insoluble, at least by any means we know. The uncertainty afflicts and inhibits some people, but their timidity is hardly justified or useful. There has seldom if ever in the world's history been a time when existence was not in some degree precarious, yet the right response to danger lies in action. Faith in the future has indeed a very great survival value. The better equipped are certainly more likely to survive than the worse equipped, and not only to save themselves but to save others.

The task of the men of science is therefore clear. It is to go ahead undeterred by any of the uncertainties. Faith in science is not incompatible with or exclusive of any other kind of faith. Indeed, there would seem to be no inconsistency in believing that scientific knowledge is itself one of the great instruments of higher ends. However that may be, duty, expediency, and the zest of living unite their voices in calling for unremitting effort, not in the certainty but in the hope and faith that knowledge may advance, mastery over environment increase, drudgery be abolished, sickness healed, the people fed and life made happier. If social and moral problems are raised they are not essentially new but part of an age-old drama, and should neither be allowed to cause despondency nor to justify obstruction or abstention. The ancient choice between good and evil is in principle unchanged by the scale or fullness of existence. Men have always had to struggle with their environment, with one another and with themselves. Not exemption from danger, hostility or temptation but the power to sustain their impact has made men what they are. The great weapons have been the things of the mind, and among the greatest of these is knowledge. While the old men dream dreams and the young men see visions we should go forward undeterred, that the dreams may become reality and the visions be fulfilled.

This commemoration is for us a great event in our history. The future is unknown. The chronicles record the actions and thoughts of men, and if, as well may be believed, thought is a creative process, then the future is more than deeply hidden : it is uncreated. The golden promises offered by the release of nuclear energy, by the exploration of outer space, by the discoveries of genetic mechanisms may in one way or another be redeemed, but the best are yet unspoken. A great upheaval of ideas may come with a complete re-orientation of science in its relation to philosophy and to the conception of possible worlds. But we know neither the day nor the hour.

It is the duty of the Royal Society not to predict, not to legislate, but to maintain within the larger community the smaller one in which creative activity can flourish. Its members owe a multiplicity of loyalties, none of which can be fulfilled without the others : to mankind in general, to their native land and to the Royal Society itself. But that is not all, for there are communities in time as well as space. The most original minds, in some sense isolated in all contemporary groupings, find their true affinites in continuing the sequence of their predecessors, and their fulfilment only in their successors. In a measure this is true not only of genius but of all men. It is what moves us in history. It is what the honouring of this occasion means.

CONSTRUCTION EQUIPMENT EXHIBITION.—In June, 1961, a new exhibition, the Construction Equipment Exhibition, will, by arrangement with the London County Council, be launched on a 25-acre area at the Crystal Palace. A new company, Construction Equipment Exhibitions, Ltd., has been formed to sponsor and promote the project. For several years, up till 1959, an exhibition of building and civil engineering plant was held in different parts of the country, organised by the Ministry of Works. Last year, however, it was announced that the Ministry wished to withdraw from the exhibition and looked to the industry for further development of the idea.

Obituary

H. E. WIMPERIS, C.B.

WE have learned with regret of the death of Dr. Harry Egerton Wimperis, which occurred at 46A, Inverleith Place, Edinburgh, last Saturday, July 16, after many months of illness. Dr. Wimperis, who was eighty-three, was the first Director of Scientific Research to be appointed by the Air Ministry. That appointment was made in 1925 and Dr. Wimperis held it until his retirement in 1937.

Dr. Wimperis studied at Cambridge, at Gonville and Caius College, where he gained a Mechanical Science Tripos, after which he went to the Royal College of Science. He became a Whitworth Scholar in 1898, acquiring practical engineering experience in the Brighton works of the former London, Brighton and South Coast Railway and at the Elswick works of Armstrong-Whitworth. In the early years of the century, Wimperis served on the engineering staff of the Crown Agents for the Colonies. When the first world war started, Wimperis was in the Royal Naval Volunteer Reserve and in 1915 he became an experimental officer in the Royal Naval Air Service. At the end of the war, he was superintendent of the laboratory established by the Air Ministry at the Imperial College of Science and Technology. His valuable work there undoubtedly led to the Air Ministry's subsequent decision to set up a scientific research directorate and it was fitting that Dr. Wimperis should be appointed to take charge of it. During the years which followed, there were many difficult problems associated with aeronautical developments to which Dr. Wimperis had to find a satisfactory solution. He was responsible, for example, for the formation of a special Air Ministry committee for surveying scientifically this country's air defences. An important result of that committee's work was the erection of the chain of radar stations which were such a valuable factor in this country's air defences during the second world war. When Dr. Wimperis retired from his directorship at the Air Ministry in 1937, he was invited to advise the Australian Government on the organisation of aeronautical research, and in 1938 he was appointed aeronautical adviser to the Australian Council for Scientific and Industrial Research. His years of retirement were very active ones and there were many demands, during the second world war, for the expert knowledge that he was at all times ready to share. Dr. Wimperis was a past-president of the Royal Aeronautical Society, before which he delivered the Wilbur Wright lecture in 1932. He was also an honorary Fellow of the American Institute of Aeronautical Sciences, an honorary Fellow and Governor of the Imperial College, a former member of council of the British Association, and a Thomas Hawksley lecturer to the Institution of Mechanical Engineers. More recently, he had served on the Chatham House atomic energy study group. Dr. Wimperis was appointed a C.B.E. in 1928 and a C.B. in 1935.

For us, the death of Dr. Wimperis brings to an end an association that has gone on happily for many years. In addition to the various books and technical papers of which he was the author, he regularly contributed to the pages of THE ENGINEER. He had an honoured place among those experts upon whom we are able to call for advice and assistance. At all times, Dr. Wimperis was ready to help. We, with many others, remember him gratefully.

LITERATURE

Zone Refining and Allied Techniques. By N. L. PARR (with a foreword by E. J. Vaughan). George Newnes, Ltd., Tower House, Southampton Street, London, W.C.2. Price 40s.

THE Admiralty gave permission for the writing of this book and many features of the equipment described have been developed by workers at the Admiralty Materials Laboratory. The Director of Materials Research, Admiralty, has written the brief foreword. The author, Norman Parr, M.I.Mech.E., F.I.M., is the head of a Metallurgical Research Division which numbers among its interests the preparation and properties of metals and materials in a high state of purity. He has employed zone refining as an essential tool and made notable personal contributions to the design and application of the equipment. He has had to study all aspects of the subject and his experience makes him uniquely qualified to write this comprehensive review of zone refining.

This process has developed rapidly during recent years, mainly because elements and compounds are required in an extremely high state of purity for the production of transistors. Purity has come to have an altogether new significance for the engineer, physicist, chemist and metallurgist. Since the original work of W. G. Pfann workers in many fields have been quick to see the potentialities of zone refining.

The present book is a welcome expansion of a monograph which the author wrote at the request of the Royal Institute of Chemistry in 1957. It aims to survey the technique, to provide information about recent laboratory methods and equipment associated with zone refining, and to encourage a wider application of the process to other fields of research and industry. The subject is very new, so much of the more recent information is still in the hands of individual and sometimes unknown workers.

This is a relatively small book as befits a new subject, and its 184 pages are illustrated with 112 figures drawn with admirable clarity. Excellent photographs are reproduced in twenty-four plates printed on glossy paper.

The subject matter is divided into eight chapters, commencing with one on the solidification process. This briefly summarises the normal metallurgical techniques with ingot moulds and the inevitable concentration of segregates and of piping, and it then leads up to the Czochralski technique for withdrawing a single crystal of metal in solid bar form from a molten bath. The next two chapters, on the new process of molten zone refining, outline the advantages of a narrow molten zone and other practical considerations. When a narrow molten zone is caused to traverse a solid bar by focusing and moving a source of heat at a given rate along the material, it is both melting and solidifying at its interfaces. Atoms of impurity are released to accumulate in the molten zone as it moves towards the tail end of the bar.

Illustrations show the effect of segregation and the influence of the speed of zoning on the removal of the impurity atoms from the freezing face. There are many techniques ; horizontal and vertical where crucibles do not spoil the material being treated, and Keck's most ingenious floating zone technique for reactive elements in which contamination must be avoided at all costs.

Chapter four, of sixty-two pages, is the longest in the book and perhaps the most valuable in that it describes the problems and gives illustrations of the choice and design of zone refining equipment. That is followed by a description of examples of zone refining equipment for simple and advanced horizontal, vertical and floating zone techniques.

There is a consideration, in Chapter Six, of the problems of handling the abnormally pure materials before and after zone refining. With vacuum and controlled atmosphere melting, casting and welding this essential handling becomes extremely complicated and difficult. Chapter Seven, on the chemical and physical examination of these extra high purity substances will be understood better by physicists than chemical analysts. The classic methods of chemical analysis are virtually useless for these extreme degrees of purity, where in some materials impurities of concentrations of 10^{-9}, and less, are significant.

The development of radioactivation analysis has probably been the all-important advance in this connection. The simplicity of the basic process appeals to one, and the ingenuity of the elaboration of these new techniques makes all this most interesting to read. A short chapter on the properties and application of high-purity materials and an index conclude the book.

Electronic engineers, metallurgists, and physicists will all be grateful to the author and to the Admiralty for this valuable little book.

Tin and its Alloys. Edited by E. S. HEDGES (with the collaboration of J. W. Cuthbertson, E. C. Ellwood, W. E. Hoare, and W. R. Lewis). Edward Arnold (Publishers), Ltd., London. Price 126s.

TWENTY-FIVE centuries ago the metal tin was an article of commerce and it is still much valued in many aspects of our daily life. As a coating of only 0·0003in thickness it has achieved extraordinary universality as a protection for foodstuff containers owing to its non-toxic character, and tin remains an essential constituent of many alloys which are much used by engineers. This new book will therefore be read with interest by people in almost all countries ; it will be very useful to industrialists. The editor writes with the especial authority on this subject of the Tin Research Institute and of the International Tin Research Council, being Director of both of those bodies.

The group of authors who have collaborated in the production of this book are all outstanding specialists. Two of them have in recent years been appointed to University Chairs of Metallurgy—Dr. Cuthbertson, who was formerly assistant director, being now in the University of Nottingham and Dr. Ellwood, who was formerly chief metallurgist, being now in the University of Glasgow. The other two collaborating authors, Dr. Hoare and Mr. Lewis, are both assistant directors of the Tin Research Institute.

Each of the eleven chapters is concluded with a bibliography which has been carefully selected and set out to help new students of the subjects. Nearly 500 publications are referred to in this way, and in the authors index. The fields covered are surprisingly wide, there being upwards of 500 items in the subject index.

These many subjects have been grouped for consideration by the various authors and the editor himself has written the preface, which describes how the book was planned, and the fifteen-page introduction. This is of general interest describing the history of tin and the growth of the tin industry. Lewis further elaborates the historical aspect of the subject in the second chapter when, in dealing with cast and wrought forms of tin, he ranges from the very long history of utilitarian and artistic pewter vessels made from alloys of tin, lead, antimony and copper in which more than half is usually tin, down to such modern things as tin foil and collapsible tubes.

The next two chapters, No. 3 by Ellwood and No. 4 by Hedges, take up some fifty pages in summarising the physical metallurgy of tin and its alloys and the chemical behaviour of tin. Then come three chapters on various aspects of tinplate. Cuthbertson in a chapter of over fifty pages describes the advantages and uses of electro-tinning. The far-reaching developments of electro-tinning, especially in huge modern works such as those recently erected in South Wales, make this a summary which should be read by many industrialists.

Hoare contributes the two chapters on the older hot-tinning process and on tinplate. He also delves into the history of this process which has in recent years achieved new peaks of production both in quantity and in uniformity of finish.

The last four chapters will be of obvious value to many engineers. That on tin-bearing alloys by Ellwood is the longest in the book and describes the properties and uses of the many Babbitt alloys. He has also written the chapter on die-casting and other tin alloys, which includes the printing metals for Linotype and Monotype without which the book could not have been produced with such commendable printing and layout.

In the informative and helpful chapter on solders Lewis lists the British Standard compositions most appropriately, for he served as the chairman of the committee which drew up these recommendations.

The final chapter on bronzes has enabled Cuthbertson to gather in to forty-four pages information regarding the many copper-tin alloys which were valued for bell founding and statuary, and those used for weapons and tools in ancient times, or as we say " in the Bronze Age." Despite the coming of the iron age bronzes remain, in their recent specifications, valuable materials of construction wherever long service without replacement is required. Indeed, tin-bearing-metals and tin-bronzes are often economical, despite their higher first cost, because they last so well and because they remain to be re-melted and re-used instead of passing away as rust.

The numerous references show how much has been written about tin and its uses but no other book is known which has gathered and surveyed so many of the historical facts and the now known properties of tin and its

alloys. This book deals with tin in the metallic state, and does not go into the details of its extraction from its ores and refining, nor does it cover chemical analysis or the compounds of tin. Fortunately for engineers this new book covers especially well the aspects in which they are naturally more interested, and it deserves to be used by them as a reference book and for general background information.

To those who use tin (and who does not ?) the book will be of use for many years to come, despite the fact that theories of corrosion are revised and new electrolytes are evolved from time to time. It is a pity that its necessarily high price will prevent many general readers from purchasing it privately because it contains much that would be interesting to any intelligent person, about, for example, ornamental pewter, church bells, organ pipes and tin cans, as well as engineering data. To libraries it is certainly worth its price.

Torsion Devices : A Survey of Instrument Parts. No. 3. By P. J. GEARY, B.S.I.R.A., " Sira," Southill, Elmstead Woods, Chislehurst, Kent. Price 21s.

THIS survey is the third of a series which includes " Flexure Devices " and " Knife-edge Bearings " by the same author. As its title implies, it is complementary to the first of these. The author has drawn on books, periodicals and reports for his material and has not confined his attention to those originating in this country. This material covers the design, construction and use of torsion devices in a wide variety of measuring instruments, and a good balance has been achieved as between torsional theory and diverse considerations of a practical nature. The reader with a problem in this field may readily extract as little or as much information as his problem demands. For those wishing to inquire more closely into the derivation of some of the many formulae quoted in the text, an extensive bibliography (40 pages) is provided at the end of the book. No systematic attempt has been made to search for relevant patents, but those which have come to light during the collection of the information are listed.

The author commences by describing the scope of the book and follows this with theoretical considerations relating to the behaviour in torsion of single elastic members having elliptical and rectangular cross sections ; he explains the contribution of the various stresses to the torsional resistance of the member. A brief note deals with variations such as the multifilar suspension

The next chapter describes torsion suspensions, their benefits and limitations, and deals at some length with problems likely to be met in their design and use. Such problems include that of the means of attachment, their insulation from vibration, the factors giving rise to inconstancy of performance, the adjustment of torsional stiffness and other relevant matters. To all of these attention must be paid if the instrument is to function in a proper manner. The author then passes from these fairly general considerations to a chapter which deals in appropriate detail with the choice of ligament material. This will be influenced by factors such as electrical resistance, resistance to corrosion, elastic after-effect and hysteresis, and dimensional accuracy. The author gives a number of references to descriptions of suitable measuring instruments and techniques. Up to this point attention has been almost exclusively directed to unifilar suspensions, and the chapter which follows is, in discussing bifilar and trifilar suspensions, necessarily self-contained in that it includes both the practice and theory of such suspensions. Another form of suspension, which is infrequently used, the coiled torsion suspension, is treated briefly in the same manner.

As its title implies, this book does not confine its attention to torsion suspensions, but also embraces two other forms of torsion device, the torsion hinge and the torsional magnifier. The former is characterised by its ability to be self-supporting in bending owing to its rigidity. When freedom from friction and backlash are important such hinges can be usefully employed. The book concludes with a description of the torsional magnifier, considerable space being devoted to the design and construction of numerous forms of it.

This book should certainly prove helpful to many whose interests require a sound approach to the design and use of the flexure devices described.

Foundation Design and Practice; An Economic View. By J. H. THORNLEY. Columbia University Press, Oxford University Press, Amen House, Warwick Square, London, E.C.4. Price 120s.

J. H. THORNLEY is a practising contracting engineer in America and in writing this book he has produced a very useful guide for the engineer who wishes to ensure that his foundation design is both practical and economic.

The author first shows what information is essential for the correct assessment of the permissible types of foundation and discusses methods of obtaining these data. He also classifies by the permissible settlement the types of superstructure. Then by reference to this classification he forms an " Elimination table " of foundation types indicating under what ground conditions and loading requirements each type is likely to be acceptable. The engineer is thus enabled to choose by a comparison of superstructure requirements and soil conditions the foundation types likely to be both suitable and economic.

A review of the main types of foundation follows, dealing with spread footings and all American types of pile, but excluding caisson, and monolith foundations. The remainder of the book gives further details of laboratory and field testing, specifications and design.

The chief shortcoming of this book is that it has been written with particular reference to the American scene and no direct reference has been made to European methods of piling. Also the economic assessment of each type of foundation is bound to be affected by the relative costs of labour and materials, and where these differ from those in America some adjustment will be necessary.

Although the last section of the book is called " Basic Design " it should not be thought that this section is exhaustive. The author deals mainly with the various ways in which piles can be used to stabilise foundations, but does not deal with alternative types. He does not set out to provide an analytical approach to this problem.

Generally, this book should be considered as a useful guide to clear thinking when first considering a new foundation. The method of classification of superstructures by the permissible settlement is useful and combined with the " Elimination tables " provides an effective way of assessing the problem with a view of finding the most profitable line of approach. Provided local rates and prices are substituted for those in the book, then the economic assessment of the various methods holds. A thorough grasp of the principles of assessment and selection as laid out by the author will greatly expedite the earlier stages in design, but it is on this basis only that the book's usefulness in this country can be judged.

Books of Reference

Vocabulary of Classical Mechanics. In five languages—Polish, German, English, French, Russian. Group O5 " Theoretical Mechanics," Warsaw : Panstwowe Wydawnictwa Techniczne (PWT), 24, Mazowiecka, Warsaw. Price zl. 30.—The *Vocabulary of Classical Mechanics* will appear in three separate volumes corresponding to the three main branches of the subject : Group O5 " Theoretical," Group 10, " Strength of Materials," and Group 15 " Hydro and Aeromechanics." The present volume deals with the most important concepts of kinematics and dynamics of the material particle and of the rigid body. It also contains the basic concepts of vector analysis in so far as these concern mechanics. In their work, the editors (Professor J. Leyko, Z. Brzoska, Z. Parszewski and J. Szmelter) have followed the recommendations of the ISO/TC 37 (ISO Technical Committee for Principles and Co-ordination of Terminology), and have drawn throughout on current technical and scientific literature. Terms are classified by number and are stated and defined in Polish, followed by translations. The vocabulary is made accessible to readers of any of the languages by its quinquelingual table of contents, and section headings, and indices in each language.

Dictionary of Terms Used in the Theory and Practice of Mechanical Engineering. Originally compiled by J. G. Horner, A.M.I.Mech.E. Eighth edition revised and enlarged by Stanton Abbey, A.M.I.M.I. Technical Press, Ltd., 1, Justice Walk, London, S.W.3. Price 27s. 6d. —This dictionary now contains two parts. The first, lists and defines terms which have come into use in recent years. The second section is a revised version of the original work. When reviewing dictionaries of this class the first tendency is to search for omissions, and over the very wide scope of engineering terminology such omissions are not very difficult to find and criticise. But criticism must always be tempered by the fact that a closer scrutiny always reveals terms which are unfamiliar. With these facts in mind it must be said that the new edition of *Horner's Dictionary*, as it has so long been well known, continues to provide a very useful work of reference.

South African Mining and Engineering Year Book. Argus South African Newspapers, Ltd., 85, Fleet Street, London, E.C.4. Price £4 9s.— A series of articles which open this book has been written by authorities on the South African mining industry and reviews progress in the industry over the past fifty years. The main directory section gives particulars of mining, industrial and financial companies ; consulting engineers and geologists ; buyers ; the principal engineering and industrial firms ; manufacturers and exporters to South Africa and Rhodesia ; and concludes with a comprehensive buyers' guide.

Books Received

Cutting Tools, Jigs and Fixtures. By H. C. Town. Odhams Press, Ltd., 96, Long Acre, London, W.C.2. Price 25s.

The Electrical Year Book, 1960. Emmott and Co., Ltd., 31, King Street West, Manchester, 3. Price 4s.

Engineering Economy. By E. Paul de Garmo. The Macmillan Company, New York ; 10, South Audley Street, London, W.1. Price 61s.

Design. Data Book for Civil Engineers. Third Revised Edition. By Elwyn E. Seelye. John Wiley and Sons Inc., New York ; Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 192s.

Non-linear Electrical Networks. By William Lewis Hughes. The Ronald Press Company, 15, East 26th Street, New York 10, N.Y. Price 10 dollars.

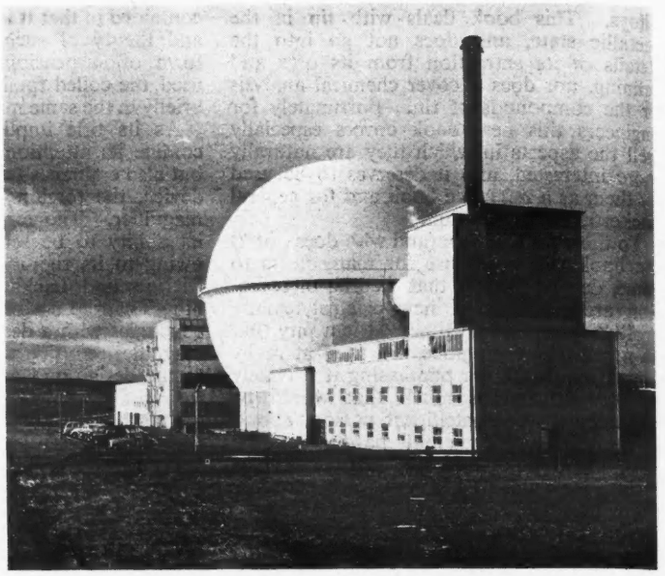
Thermodynamics and the Heat Engine. By Donald H. Marter. Thames and Hudson, Ltd., 30, Bloomsbury Street, London, W.C.1. Price 63s.

Nuclear Power Progress in Britain

U.K. ATOMIC ENERGY AUTHORITY'S REPORT, 1959-1960

No. I

The sixth annual report of the United Kingdom Atomic Energy Authority, published last week, covers the year ended March 31, 1960. The following extracts taken from the report deal with the Calder Hall and Chapelcross reactors (which are now operating with a thermal output 15 per cent above the design value, and with an operating availability of more than 80 per cent) and give a review of the reactor development programme. This programme includes the "Magnox" reactors, the Advanced Gas-Cooled Reactor at Windscale, the fast reactor at Dounreay (illustrated here), the High-Temperature Gas-Cooled Reactor, the Steam Generating Heavy-Water Reactor, marine reactors and research reactors.*



AT the beginning of the year under review five reactors were in operation; four at Calder and one at Chapelcross. The remaining three reactors at Chapelcross were brought to full power during the year and at the end of the year all eight reactors were operating in accordance with production programmes. The electricity sent out from the Chapelcross station now represents some 20 per cent of the base load of the South of Scotland Electricity Board.

Improvements in reactor operating procedures resulted in significant increases in both the availability and the rating of the reactors. The availability was greatly increased by a 50 per cent reduction in scheduled shut-down time achieved by streamlining of charge and discharge schedules and detailed planning of their integration with maintenance schedules. Including the scheduled closures for recharging the reactors, an operating availability in excess of 80 per cent was achieved; this is an important achievement in relation to the major use of this type of reactor as a base-load power station. The thermal output of the reactors was increased to 15 per cent above the design capacity; but reblading of the turbines is necessary to allow an equivalent increase in the electricity generation.

Reactor trials showed that the present maximum fuel element operating temperature can be raised with no loss of reliability.† Modified operating conditions are therefore being introduced which will further increase the rating of the reactors.

Significant improvements in commissioning measurements were achieved as the result of advances in the techniques of control rod calibration, in the determination of reactor shut-down characteristics, and in methods of studying the coolant flow pattern.

The development of reactors beyond the present type falls into two stages. The first envisages reactors with low capital costs obtained with the aid of slightly enriched fuel. The second stage is the development of reactors having both low capital costs and small net consumption, or even a net gain (breeding), of fissile material. For the first stage the Authority has concentrated on the advanced gas-cooled reactor and for the second on the fast breeder reactor and the high-temperature gas-cooled reactor.

Other work on reactors included a design study of a steam-cooled, heavy water reactor and a variant of it, the steam generating heavy water reactor. Schematic designs for various systems of marine propulsion were prepared.

"MAGNOX" REACTORS‡

Work on this reactor system remained the largest element in the Authority's reactor development programme. It was directed to ensure the maximum reliability and the lowest possible generating costs for "Magnox" systems; for although the cost of power from the earlier "Magnox" stations will be somewhat higher than that from the latest design of coal-fired station, the "Magnox" system still retains scope for substantial reductions in power costs.

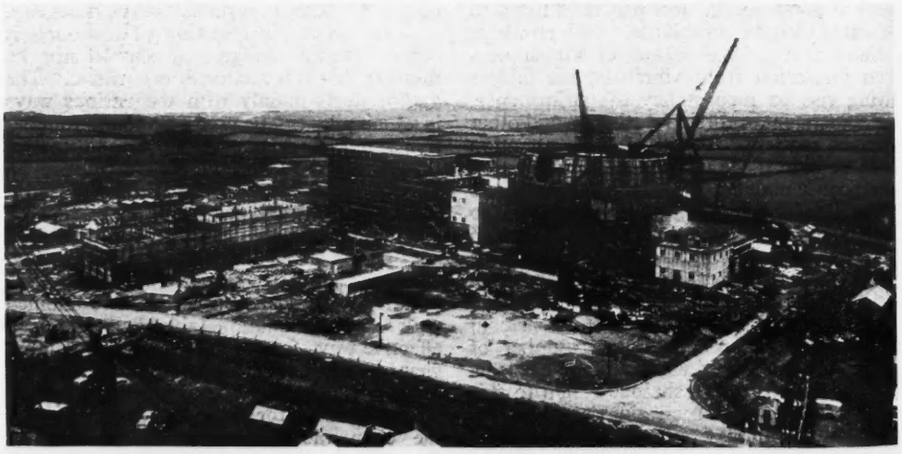
Reactor Physics.—Two aspects of reactor physics have received considerable attention; changes in reactivity with length of irradiation and the moderator temperature coefficient, that is, the inter-relation of reactivity with the temperature of the graphite moderator, and the implications of these changes upon the design of the reactor control systems.

The Calder reactors have provided direct information on the build-up of plutonium, the effects of which were forecast from basic studies. These studies are continuing with particular emphasis on the effects of plutonium on neutron spectra, flux distribution and temperature coefficients, and facilities have been set up for the study of lattices containing plutonium and uranium at temperatures up to 400 deg. Cent. As part of the programme the fuel charge in one Calder reactor was left in the reactor much longer than usual (as described below) in order to simulate the nuclear conditions characteristic of the civil reactors. Measurements of the variations in reactivity as irradiation proceeds are valuable checks on theoretical predictions. In addition the B.I.C.E.P.§ programme as described in the fifth annual report continued, and fuel plates spiked with plutonium have been used for studies of the behaviour of reactor lattices with a plutonium content comparable to that built up in the operation of a civil reactor.

As the plutonium content builds up with increasing irradiation, an increase in the temperature of the moderator leads to an increase in reactivity; the reactor is then said to have a positive temperature coefficient, and, above a certain value, this accentuates tendencies to vary from the normal operating levels of the reactor. Theoretical and experimental studies were made to determine the best control systems for reactors with positive temperature coefficients. As part of these studies, the Authority has during the past year set up at Risley a large general purpose

‡ The gas-cooled, graphite-moderated reactors under construction for the electricity generating boards are known as "Magnox" reactors from the magnesium alloy used to can the natural uranium fuel.

§ British Industries Collaborative Exponential Programme.



Advanced Gas-Cooled Reactor A.G.R. under construction at Windscale, Cumberland

* Her Majesty's Stationery Office. Price 5s..

† Fuel element operating temperatures have been increased from 408 deg. to 418 deg. Cent., and it is hoped to reach 438 deg. Cent.

computing centre. The work has shown that, to control variations resulting from a positive temperature coefficient, different parts of the core may have to be controlled separately: multiple-zone control systems have been designed for the " Magnox " reactors. Special control experiments were also carried out at Calder Hall and Chapelcross and although these reactors are not large enough to require separate control of different parts, the experiments have confirmed the theoretical basis of the computer calculations.

Graphite Moderator.—In the past, knowledge of the rate of build-up of Wigner energy under the operating conditions of the civil reactors was limited, and conservative design specifications were introduced after the Windscale incident in order to ensure a safe operating life of twenty years for the civil stations. To give this guarantee with the knowledge then available required raising the bulk graphite temperature by sleeving the fuel channels of civil stations. Subsequent experiments both in materials testing reactors and at Calder Hall showed that the rate at which Wigner energy builds up decreases more rapidly than had been expected as irradiation proceeds. On the strength of this information the Authority decided to withdraw its recommendation that fuel channels should be sleeved.

The experiments on Wigner energy storage also gave considerable additional information on dimensional changes in graphite known to be caused by irradiation and should lead to improved designs of graphite structures.

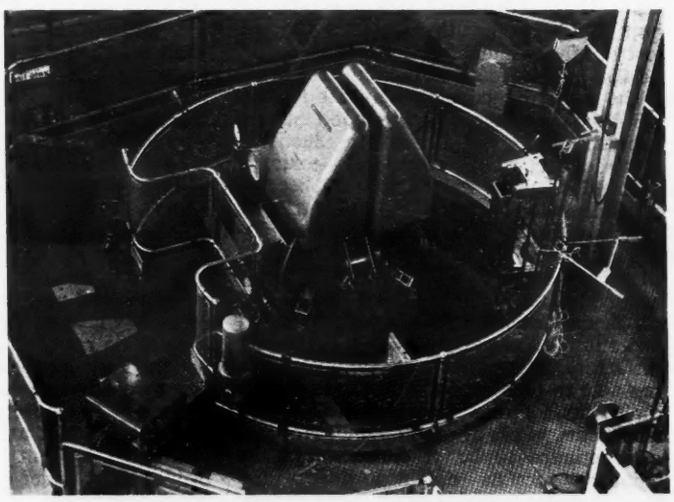
As pointed out in the fifth annual report the reaction between graphite and carbon dioxide under the influence of irradiation has been studied. Further information from the Calder Hall reactors has been supplemented by measurements on samples in the materials testing reactors " Dido " and D.M.T.R. The work has shown that this reaction is not likely to present problems in " Magnox " reactors.

Fuel Elements.—The main technical problem outstanding is civil fuel element performance under irradiation. A major source of background information is provided by study of the performance of Calder fuel elements in the reactors at Calder Hall and Chapelcross. Since these reactors were commissioned nearly 200,000 elements have been loaded and irradiated. These large numbers provide a useful and statistically sound basis for assessing the reliability of the fuel elements ; the failure rate from all causes has in fact been well below 0·1 per cent. Nevertheless a large number of the irradiated elements has been examined in order to establish the causes leading to failure. In addition, an important programme has been set in hand for the testing of civil fuel elements in which groups of reactor channels have been loaded with fuel elements designed to simulate those proposed for the civil " Magnox " power stations. These experiments, which are continuing, have proved invaluable in revealing, at an early stage, weaknesses in design such as excessive vibration of the fuel elements in the coolant gas stream and will enable remedial action to be taken before large-scale production is due to start.

The fifth annual report pointed out the importance of ensuring that fuel in the civil stations has an available heat content averaging 3000MWD/Te. As mentioned above, one of the Calder Hall reactors is being used for a special experiment to investigate physics problems associated with long burn-up. By March, 1960, the average irradiation level of Calder fuel elements in this reactor had reached over 700MWD/Te, a number of channels had exceeded 1000 MWD/Te and a number of elements had achieved 2000MWD/Te. (The design life of Calder elements is much lower than that for civil station fuel.) Performance in the hot parts of the reactor was very satisfactory but, as expected, numbers of elements failed in the coolest region due to the insufficient ductility of Calder-type " Magnox " when subjected to slow straining by the growth of uranium. " Magnox " for civil fuel elements has a finer grain and has been chosen to give a can of greater ductility at low temperatures.

The other phenomenon which may limit fuel element life is the swelling of uranium at high temperatures due to the agglomeration of fission product gases. Swelling has not shown at Calder but it may well apply to civil fuel at high burn-ups, particularly if fuel is subjected to thermal cycling. The design of the civil fuel elements allows for this swelling and for the decreasing ductility at low temperature, and information from a continuing research programme indicates that civil fuel elements should have an available heat content equivalent to 3000 MWD/Te when equilibrium has been achieved.

The fuel development programme increasingly requires the examination of large numbers of highly irradiated fuel elements. To deal with these and the very large numbers which will arise from the operation of civil " Magnox " stations at home and abroad, the Authority has begun the construction at Windscale of very large and heavily shielded caves for examining fuel elements and of metallurgical laboratories, utilising the blower houses of the original Windscale piles.



The light-water-moderated research reactor "Herald" at the A.W.R.E., Aldermaston, started operation in February, 1960

Advanced Gas-Cooled Reactor

As the next development in gas-cooled reactor systems, the Authority has proceeded with the advanced gas-cooled system (A.G.R.) This reactor is fuelled with slightly enriched uranium oxide pellets canned in stainless steel or beryllium ; it is moderated by graphite and cooled by carbon dioxide. The coolant gas outlet temperatures will be about 150 deg. Cent. higher than those of the " Magnox " system. Recent studies have confirmed that the A.G.R. system offers the best prospect for the early achievement of competitive nuclear power in the United Kingdom.

Prototype A.G.R.—Construction work on the prototype advanced gas-cooled reactor at Windscale (illustrated) has continued, and should be completed by the spring of 1961 as planned.‖

The most important role of the prototype reactor will eventually be the study of the irradiation performance of large quantities of fuel elements. The experience gained in the development of fuels for the " Magnox " system has underlined the necessity for such large-scale testing.

Reactor Physics.—The construction at Windscale of the experimental zero-energy high-temperature research reactor " Hero " was started in September, 1959. It will be used to study the physics of the A.G.R. system. Initial experiments will be carried out on beryllium and stainless-steel-clad uranium oxide fuels. Later experiments will use reactor fuel containing plutonium to simulate the state of A.G.R. type reactors after prolonged burn-up of fuel. Differential heating and cooling arrangements will enable fuel and moderator temperature coefficients to be determined. Meanwhile, experimental work is in progress using exponential stacks.

The formation of plutonium as fuel burns leads to a positive moderator temperature coefficient of reactivity in the A.G.R. as in the " Magnox " reactors. In view of the higher rating, and because the beryllium used as a canning material is also significant as a moderator, the problems of control are increased. From experimental and theoretical work that has been carried out, it has been shown that a simple system will suffice to control the power output of the Windscale prototype A.G.R. However, power-producing A.G.R. reactors would be appreciably larger, and the situation would be more complicated. A considerable amount of work, both theoretical and experimental, has therefore been devoted to the control of large A.G.R. systems. To facilitate control the coolant gas may be passed through the moderator before introducing it to the fuel channels ; by this means the temperature of the moderator is maintained at a level close to that of the inlet gas temperature, and thus suffers a much smaller temperature change with change of power level. This re-entrant core arrangement has also been adopted for the Windscale prototype A.G.R., in order to demonstrate its value for application to the larger power production reactors. The adoption of the re-entrant core will still

‖ The A.G.R. at Windscale was described in THE ENGINEER, June 10 and 17, 1960.

leave the temperature of the core sufficiently high to avoid the build-up of stored energy in the graphite.

Although, as stated above, the carbon-dioxide/graphite reaction is a negligible problem for the " Magnox " reactors, it is known that this reaction increases with flux and coolant gas pressure in such a way that under the more stringent conditions in the A.G.R. the loss of graphite over the lifetime of a reactor would no longer be negligible. A large programme of work has been undertaken on this problem, utilising both the Authority's material testing and production reactors. It has been established that the presence of 1 or 2 per cent of carbon monoxide in the coolant produces a marked reduction in the loss of graphite under irradiation.

Fuel Element Development.—Until last year, much of the information available on enriched uranium oxide as a fuel came from the United States and from Canada. While co-operative programmes on this material have continued during the last year, an increasing amount of information has become available from irradiation work carried out by the Authority in the United Kingdom. Development of large-scale manufacturing processes for slightly enriched uranium oxide pellets has been undertaken and already several tonnes of such pellets have been successfully made to design specification. As part of this work, a continuously operating sintering furnace has been developed which has greatly improved the efficiency of the manufacturing process.

Canning Materials.—Beryllium was chosen as the preferred canning material for the A.G.R. system because of its good nuclear properties and good thermal conductivity. Its disadvantages are that it is toxic, it becomes less ductile under irradiation because of the formation of helium, and it contributes to the positive temperature coefficient problems mentioned above.

The beryllium laboratories of the Authority have had considerable success in the last year in the development of production and fabrication processes for beryllium under satisfactory safety standards. Industry has been able to take over the processes, and is now manufacturing beryllium tubes and components. Loss of ductility under irradiation continued to be of concern, but the preliminary results obtained during the year from the large irradiation programme were reasonably encouraging.

In parallel with the development of beryllium as a canning material the use of stainless steel is being investigated. The disadvantages of stainless steel (high neutron absorption and low thermal conductivity) have been mitigated by the development of greatly improved heat transfer surface, which enables the total amount of stainless steel to to be kept small. Both types of canning will be tested in the Windscale A.G.R.

Civil A.G.R. Study.—Design studies were carried out to optimise the A.G.R. system for large stations. These studies suggested that higher thermal efficiencies would be possible than were earlier assumed. These benefits derive from development of improved heat transfer surfaces, from re-optimisation of temperature and steam conditions, from improved pressure vessel design and from a re-assessment of power plant efficiencies. In order to check that forecasts for a civil A.G.R. power station were based on sound assumptions, a further study was carried out by the Authority jointly with the Central Electricity Generating Board. This has confirmed the promise of considerable reductions in capital cost and in total cost of power generated compared with " Magnox " stations.

Fast Reactor

The fast breeder reactor system offers the prospect of low-cost power, because of the potentially low capital costs and low fuel cost. The capital cost should be low because the very high heat rating of the fast reactor leads to a small core and because a high-operating temperature gives a high thermal efficiency. The eventual fuel cost should be low because these reactors will breed more plutonium than they consume. These fundamental advantages are indisputable, but a great deal of work will be necessary to establish that they can be commercially exploited. However, on the basis of the present information, the Authority believes that a power-producing fast breeder reactor system will be the best and most economic way of using plutonium. The plans for the development of fast breeder reactor systems are as follows.

Information and experience are to be gained on the Dounreay fast reactor, which became critical in November, 1959. This reactor will gradually be worked up to full output. It will then provide the necessary environment for testing various designs for fuels and fuel elements suitable for a full-scale power-producing fast reactor. A prototype power-producing reactor may be built for operation about the year 1967, the development of which will enable a commercial power station to be specified. Whereas the fuels for the prototype will be tested in the Dounreay fast reactor, the neutron physics will require study in a facility which allows ready reassembly of the core into various configurations. It will not be possible to do this in the Dounreay fast reactor once it has come to full power, and a zero energy facility will be provided.¶

Dounreay Fast Reactor.—Following the first stage in the commissioning the charge of 120 tons of sodium and potassium alloy was prepared and charged into the primary and secondary heat exchangers. The reactor was then made ready for operation after a very detailed testing programme had been carried out to ensure the reliability of every component. The reactor became critical in November, 1959, and was then run at low power (100W), but at high temperature, in order to test under operating conditions the reliability of the components and safety devices. Some trouble was experienced through formation of oxides in the coolant, and improvements were made to the oxide clean-up circuits. In general, experience during start-up confirmed the Authority's confidence in the potentialities of this reactor system.

During the initial stage of low-power operation, the physics programme required for testing the control problems of fast reactor systems was started. At the conclusion of this initial low power stage, the reactor was shut down for the programmed modifications to the core, involving the fitting of an adapter to part of the core, so that other, more advanced, types of fast reactor fuel elements can be tested.

A start has been made during the past year on the study of some suitable fast reactor systems for civil power production, and the optimisation of the characteristics of such systems. These studies will pave the way for the investigation of the design of a prototype, on which effort will be increasingly devoted in the coming year.

¶ Plans for this experiment (to be known as " Zebra "—Zero Energy Breeder Assembly) have been announced recently, as reported in THE ENGINEER, July 7, 1960.

High-Temperature Gas Cooled Reactor

The high-temperature gas-cooled reactor (H.T.G.C.) is an attempt to reduce nuclear power costs by carrying the technology of the gas-cooled, graphite-moderated reactor system beyond the limitations of the A.G.R. It looks an increasingly promising source of power for the 1970s.

In the H.T.G.C. reactor high heat rating per kilogramme of fuel and high gas temperature are achieved by using an all-ceramic fuel element in which a can of graphite surrounds a graphite sleeve or rod which is impregnated with fuel ; the moderator itself thus forms the heat transfer surface. The primary fuel is highly enriched uranium-235, but net consumption of fissile material can be reduced by incorporating thorium in the fuel elements for conversion under irradiation into the fissile material uranium-233. It might be possible to start the system with plutonium, rather than with uranium-235.

The " Dragon " experiment, a joint project under the auspices of the Organisation for European Economic Co-operation will test the principles of the H.T.G.C., and almost all the effort devoted by the Authority to this system during the year has been related to this experiment at Winfrith. Good progress was made during the year in setting up the project, in the design of the experimental H.T.G.C. reactor, and in the associated research and development work.

The " Dragon " experimental reactor will test the major items of technology : fuel elements, gas-cooling circuits and methods for purging the system of fission products. It will operate initially with uranium highly enriched in the isotope 235 as fuel and thorium as fertile material. On account of its small size, the " Dragon " reactor will not show a high conversion factor, but nevertheless should give valuable information on the physics involved and a reasonably long burn-up for the fuel elements.

Because of its high operating temperature, the H.T.G.C. system is designed to use graphite in place of metal for canning the fuel. Ordinary reactor graphite is not suitable for the fuel element can because it is permeable and would allow fission products to diffuse into the coolant gas and so require complex plant to purge the gas of the fission products. The Authority, therefore, initiated an extensive programme with the collaboration of industry and of the Royal Aircraft Establishment for the development of graphite with low permeability but sufficiently free from neutron absorbing impurities. Graphite of the required degree of impermeability has now been made, but its performance under prolonged irradiation has yet to be established. The study of irradiation behaviour and of the mechanism by which fission products diffuse through graphite is, therefore, an important feature of the present programme.

Uranium/thorium/graphite fuel elements have been irradiated at high temperatures up to a high proportion of their design life, and have given encouraging results ; dimensional changes were small, and the changes in permeability and thermal conductivity of the graphite container were determined.

The zero energy reactor " Zenith," which was designed to support the work on the H.T.G.C. was completed. Commissioning started in September, 1959, and over a period of a month the temperature of a dummy core was raised to 750 deg. Cent. by electrical heating of the circulating gas (nitrogen). It proved necessary to modify

the heating arrangements, but the reactor physics work continued with the reactor unheated. Fuel elements were loaded into the core during November and December, and the reactor became critical shortly before Christmas. Measurements have been made to determine the flux pattern and the effectiveness of the control devices in a core similar to that to be used in the " Dragon " reactor.

Steam Generating Heavy Water Reactor

During the last year, in the course of the design study of a steam-cooled heavy water (S.C.H.W.) reactor prototype, a further development of this concept has taken place ; instead of generating the steam in external heat exchangers, it is now proposed that the water should be evaporated in the reactor core itself. This idea of a steam generating heavy water reactor (S.G.H.W.) offers savings on capital cost since the light water coolant in the core would contribute towards moderation and the investment of heavy water would be reduced ; furthermore, there would be no need for external heat exchangers.

The immediate object of study is a reactor using water and steam coolant in pressure tubes inserted through a heavy water container, steam being separated outside the reactor before being returned for superheat. The combination of the two different moderators and the use of the boiling principle introduces novel problems in reactor physics and stability, and the performance cannot at present be predicted to the required accuracy. Preliminary physics experiments will be carried out in " Dimple " to assist in assessing the feasibility and performance of the system. Work has also proceeded on experimental investigations of heat transfer problems in water/steam systems and on a feasibility study of a possible prototype power reactor.

A decision on whether to proceed with the construction of an S.G.H.W. will depend upon the results of this further work which will be reviewed later this year, and upon the availability of both technical manpower and financial resources.

TABLE—*Atomic Energy Authority's Reactors as at March* 31, 1960

Research and Experimental Reactors

Name	Location	Date of Start-Up	Peak Neutron Flux	Maximum Heat Output	Moderator	Coolant	Fuel	Purpose
1. " Gleep " ...	Harwell	1947	$3{\cdot}7\times10^{10}$ thermal n/cm²sec.	100kW	Graphite	Air	Natural uranium metal and oxide	Routine graphite and uranium quality testing ; research with oscillator ; biological irradiations
2. " Bepo " ...	Harwell	1948	2×10^{12}	6MW	Graphite	Air	Natural uranium	Isotope production and general radiation source
3. " Dimple "...	Harwell	1954	About 10^{8}	100W	Heavy water	None	Varies	Thermal reactor and pile oscillator studies
4. " Lido " ...	Harwell	1956	10^{12}	100kW	Light water	Light water	Uranium 235	Thermal reactor studies, including shielding
5. " Dido " ...	Harwell	1956	$1{\cdot}4\times10^{14}$	10MW	Heavy water	Heavy water	Uranium 235	Nuclear reactor material studies, isotope production, neutron physics, radiation chemistry
6. " Pluto " ...	Harwell	1957	$1{\cdot}4\times10^{14}$	10MW	Heavy water	Heavy water	Uranium 235	Nuclear reactor material studies, isotope production, neutron physics, radiation chemistry
7. D.M.T.R. ... (" Pluto " type)	Dounreay	1958	$1{\cdot}4\times10^{14}$	10MW	Heavy water	Heavy water	Uranium 235	Studies on nuclear reactor materials
8. " Horace "...	Aldermaston	1958	About 10^{8}	10W	Light water	Light water	Uranium 235	To obtain basic nuclear information on " Herald "
9. Fast Reactor	Dounreay	1959	—	60MW	None	Sodium potassium alloy	Enriched uranium plutonium	Development of fast reactor technology (reactor physics, fuel elements and coolant handling)
10. " Zenith" ...	Winfrith Heath	1959	10^{6} thermal n/cm² sec.	100W	Graphite	None—Nitrogen used as heating gas	Ceramic elements containing highly enriched uranium oxide	Reactor physics investigations for high-temperature gas - cooled systems (maximum temperatures, 800 deg. Cent. in core, 400 deg. Cent. in reflector)
11. " Herald " ...	Aldermaston	1960	10^{14}	5MW	Light water	Light water	Uranium 235	Neutron physics, radiochemical and nuclear reactor materials studies

Research and Experimental Reactors under construction

12. AGR	Windscale	1961	$2{\cdot}5\times10^{13}$ thermal n/cm² sec.	100MW	Graphite	Carbon dioxide	Enriched uranium oxide	To study the advanced gas-cooled power reactor system and to test fuel elements for the system
13. " Hero " ...	Windscale	1961	—	A few Watts	Graphite	Carbon dioxide (used as heating gas)	Enriched uranium oxide	Reactor physics studies for the advanced gas-cooled reactor system

Research and Experimental Reactors of which construction has been approved

14. " Nestor " ...	Winfrith Heath	December, 1960	10^{11} n/cm² sec.	10kW	Light water	Light water	Enriched uranium-aluminium alloy	Source of neutrons for sub-critical assemblies
15. " Hector " ...	Winfrith Heath	Mid 1962	3×10^{8} n/cm² sec.	Up to 100W	Graphite	Carbon dioxide (used as heating gas)	Permanent fuel : Enriched uranium-aluminium alloy. Central core : variable.	Oscillator Reactor — reactivity measurements on materials and fuel elements

Plutonium/Power Producing Reactors (in production)

16–19. Calder ... (two stations " A " and "B") (four reactors)	Calderbridge	Station "A" 1956 Station "B" 1958	—	200MW per reactor (37MW [E] net)	Graphite	Carbon dioxide	Natural uranium	Plutonium and power production
20–23. Chapelcross	Annan	1958 (1st reactor) 1959 (reactors 2, 3 and 4)	—	200MW per reactor (37MW [E] net)	Graphite	Carbon dioxide	Natural uranium	Plutonium and power production

NOTE : " Zeus " was dismantled in September, 1957. " Zephyr " was dismantled in June, 1958. " Hazel " was dismantled in September, 1958. " Nero " was dismantled at Harwell and is to be re-erected at Winfrith in 1960. "Neptune " ceased operation in June, 1959.

Marine Reactors

Merchant Ships.—The Authority was represented on the Committee for the Application of Nuclear Power to Marine Purposes and its sub-committees which assessed proposals put forward to H.M. Government by industry for a 65,000-ton commercial tanker. H.M. Government subsequently invited certain firms to make more detailed proposals in the form of tenders to the Ministry of Transport. The Authority has undertaken to help in the assessment of these tenders when they are received. The two reactor systems for which tenders were invited were a boiling water reactor and an organic-liquid-moderated reactor.

The Authority has made design studies of possible marine reactor systems for the above committee, and from this work has drawn the general conclusion that reactor systems on known techniques will not compete on an economic basis with conventional ship propulsion. Considerable improvements will be required before economic operation is likely. The Authority is continuing studies of organic-liquid-cooling and boiling water systems, and the possibilities of steam generating and steam-cooled heavy water systems for ships.

Research Reactors

Most of the Authority's research reactors (tabulated here) fall into one of two categories : those which deal with the neutron physics of various reactor assemblies, i.e. the sub-critical assemblies and zero energy reactors ; and the materials testing reactors, where the object is to produce a flux of radiation into which samples can be placed for irradiation testing. The use of several of the sub-critical and zero energy facilities in elucidating the neutron physics of various reactor systems has already been referred to in previous paragraphs.

Two reactors which fall outside the common categories deserve mention : " Gleep," Britain's first reactor, has continued to be used extensively to check the nuclear quality of commercially produced graphite ; it has also been used to measure the reactivity changes in irradiated fuel elements. The swimming pool reactor " Lido " is being used to test the effectiveness of various shielding materials and in the study of the neutron physics of reactor lattices ; the team doing this work has been augmented recently by staff from the consortia.

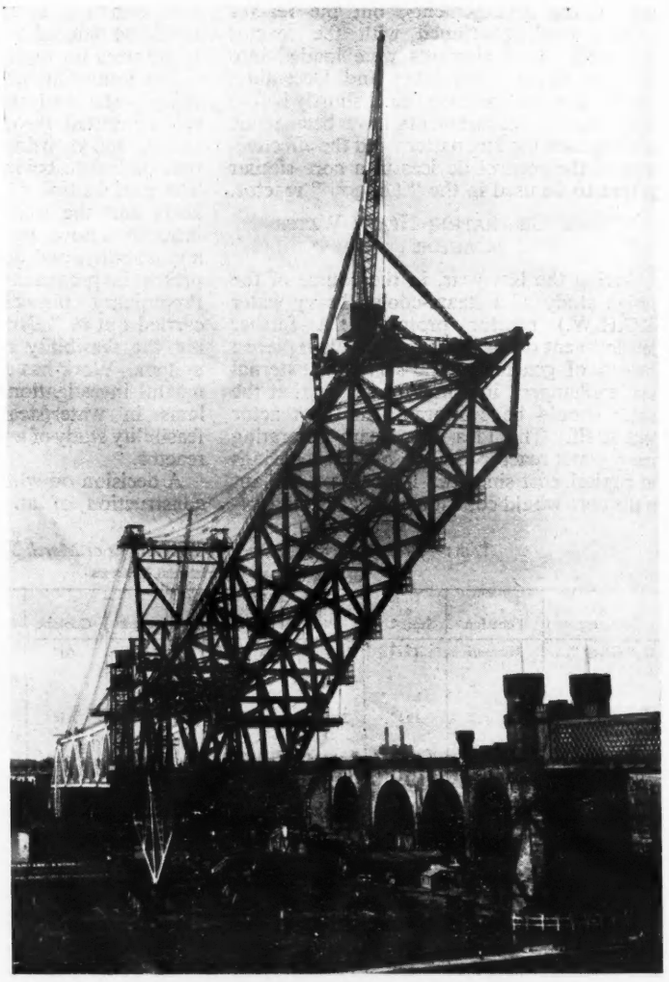
Materials Testing Reactors.—Irradiation work carried out in the Authority's three large materials testing reactors (" Dido," " Pluto " and D.M.T.R.) has been increasing in significance. For example, these high flux reactors have played a very important role in accelerating tests of the behaviour of graphite and of small specimens of fuel and canning materials.

The light-water-moderated research reactor " Herald " (illustrated on page 145) at Aldermaston started operation on February 29, 1960.

The past year has seen an increase in the demand for irradiation work and the Authority has found it necessary to plan for increased use of materials testing reactors overseas.

(*To be continued*)

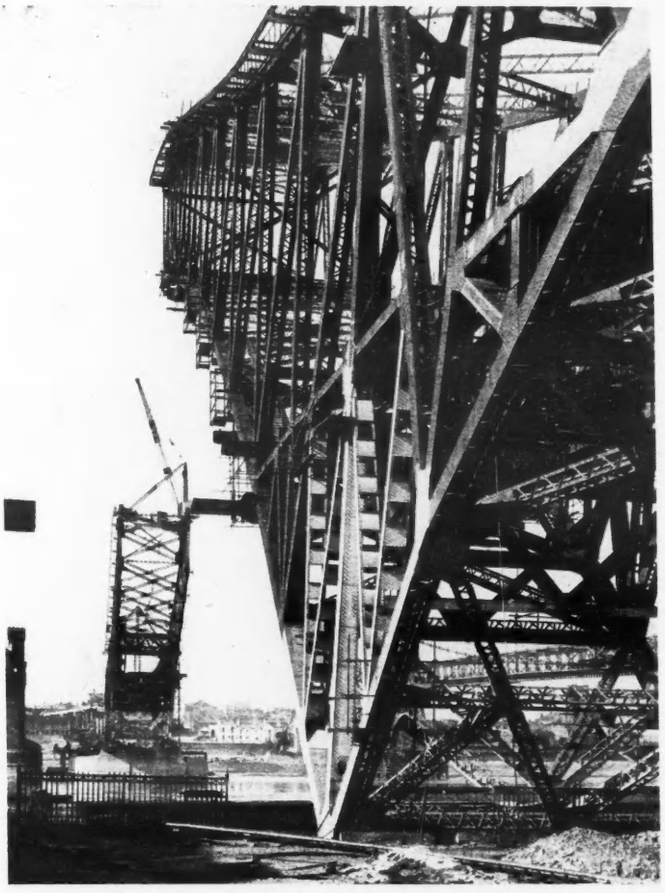
Progress of the Runcorn-Widnes Bridge



RIGHT : Erection on the Runcorn bank with the side span painted (the bridge steelwork is to be light green in colour). The cable mast and forestay and backstay cables are in position. The mast steelwork is largely steel ordered for the deck structure of the bridge, and adapted for temporary use in the mast. Similarly, cables ordered as ties, on which the deck will be suspended below the arch, have been temporarily utilised in their anchorage system, which will, of course, be dismantled as soon as the arch is closed. Temporary works for erection include a lift for men up to the top chord level, which can be seen on the left of the bridge, close to the skewback ; at the top chord a platform with handrails extends across the bridge, and from this point, the top chord members have safety nets below them on one side, and a handrail on the other. The cantilevered materials track can be seen to the right of the bridge at top chord level. This track is also well shown in the heading illustration opposite. Pieces of steel are lifted by the derrick to a trolley on this track, and thence taken up to the creeper crane for erection in the arch. Temporary sway frames can also be discerned in this view.

BELOW : Erection of the two half arches in progress. On the Runcorn side (i.e. in the background) nine panels are complete, the creeper crane has been brought forward, and work is proceeding on the erection of the anchorage cables from the arch at panel point 7 to the temporary cable mast, and from the mast to the rock anchorages behind the side span. Erection of the seventh panel of the arch on the Widnes side is in progress, and most of the concrete deck has been constructed on the side spans. The first of the deck crossbeams is shown in position on each side, suspended on its ties below the main arch. The second of these beams is also to be seen suspended at a higher level on temporary ties. At this point the normal cross bracing of the arch is interrupted to allow the roadway to pass through it, and thus additional bracing is built round the roadway clearance lines ; with this special configuration of the steelwork, it is not possible to lower these two beams through the arch from the creeper crane when it returns down the completed arch, as is to be done elsewhere.

Progress of the Runcorn-Widnes Bridge



Construction of a steel arch bridge with a main span of 1082ft, crossing the River Mersey and the Manchester Ship Canal between Runcorn and Widnes, is now well advanced. Although notable as the first structure of its size and span to be built in this country since the war, the bridge does not depart substantially from established engineering practice, and it could perhaps be described as following a classical pattern in its design and construction. The main structure is of high-tensile and mild steel, and nearly all the site joints are riveted.

RECENT progress in building the great steel arch between Lancashire and Cheshire, which will replace the transporter bridge nearby as a road crossing, is well shown in the illustrations accompanying this article. The main structure is also shown in elevation in the drawing, from which it can be seen that the main span is of 1082ft, and is a two-pinned trussed arch, continuous with two side spans, each of 250ft, which, structurally, are propped cantilevers. The roadway is carried on the bottom chords of the cantilevers, and suspended from ties below the main arch. The graceful form of this configuration is immediately apparent.

The Runcorn-Widnes bridge will be the longest arch span in Europe. Only the Bayonne bridge (New York) and the Sydney Harbour bridge, which have spans of 1652ft and 1650ft respectively, are longer in this category. The bridge is also of special interest since its original design was for a suspension bridge, but wind tunnel tests showed that aerodynamic buffeting would be experienced from the railway bridge close to to it.* This is probably the first time that this problem has been encountered in the aerodynamic study of suspension bridges, and the complication which it brought with it led to the decision to change to the present structure.

Until a couple of years ago, the Runcorn-Widnes bridge was the only really large post-war bridge scheme which this country had seen. Overseas, however, British engineers were more active ; and their work since the war has included one large steel arched bridge, the Volta River bridge at Ghana, which has a main span of 805ft, and is of advanced design in many respects. Overseas bridge work being carried out by British firms at present includes the 1000ft span arched bridge in concrete under construction at Gladesville in New South Wales.

Approaches to the Bridge

The Runcorn approach viaduct commences with a roundabout at a junction with a new road leading towards Northwich which is being constructed by the Cheshire County Council. The viaduct consists of two steel plate girder bridges over the Bridgewater Canal and High Street, Runcorn, with spans of 108ft and 50ft respectively, thirteen reinforced concrete spans varying in lengths from 70ft to 81ft 6in, and a plate girder span adjoining the main bridge of 65ft.

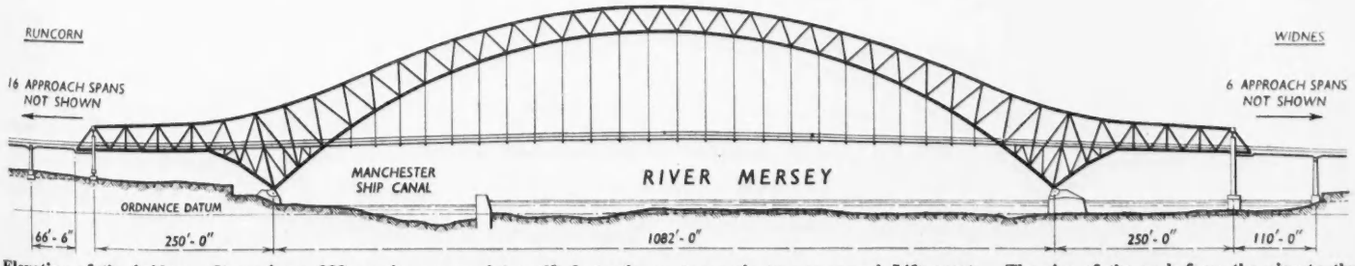
The Widnes approach viaduct also joins a further new viaduct and embankment which is being constructed by the Lancashire County Council. It consists of a section of fill, retained by reinforced concrete-walls, six reinforced concrete spans of 83, ftand a plate girder span adjoining the main bridge of 87ft.

The total length of the bridge is thus 4400ft.

The design of the reinforced concrete viaducts consists of four beams supporting the deck slab, the beams being continuous over three spans. Due to the very confined working room the beams were precast in sections on the ground, directly alongside their final position. Two lengths of beam were produced : 47ft, to be positioned over the fixed piers, and 23ft over the free piers. These sections were lifted into position by a lorry-mounted crane and supported by military trestling. The precast beams were joined together by sections cast *in-situ*. After the completion of the beams the 8in road slab is cast between them and the cantilever footpath is cast *in-situ* on each side.

As can be seen from the illustrations of

* See The Engineer, May 13, 1955, "Aerodynamic Buffeting of Bridges" by C. Scruton.



Elevation of the bridge. It carries a 33ft carriageway and two 6ft footpaths on two main trusses spaced 54ft apart. The rise of the arch from the pins to the top chord at the crown is 253ft, and the truss depth is 106ft at the springing and 35ft 3in at the crown

the approach viaducts, the reinforced concrete structures are massive in scale. The "T"-shaped piers carrying the beams vary in height from 41ft to 17ft. Construction of these viaduct spans includes the use of 2in round steel bars as reinforcement, and of expansion joints comprising steel and rubber sandwiches arranged with the layers in a vertical plane, such that movement at the joint is taken up by the rubber.

Arch Foundations

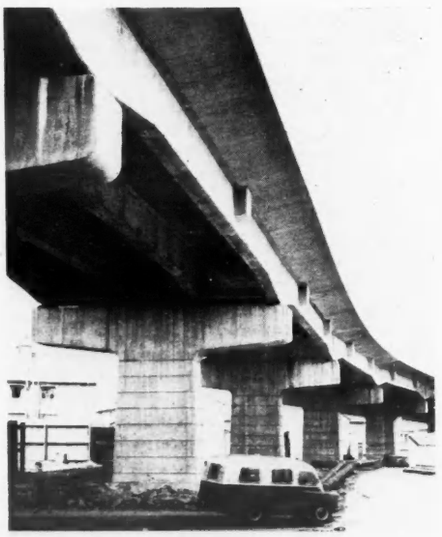
Under the most severe live loading and wind, the maximum thrust from the arch at each bearing will be about 3500 tons at approximately 45 deg. to the horizontal.

At Runcorn, the main pier carrying the thrust of the arch has been constructed on the shore adjacent to the Manchester Ship Canal bank. This pier is founded on soft red sandstone, 14ft below the level of the canal. It contains 4000 tons of concrete.

On the Widnes side, the main skewback pier and the pier supporting the end of the side span are on the foreshore of the River Mersey, where there is a tidal rise of 20ft at spring tides. These piers were built inside steel-sheet-piled cofferdams. The skewback pier cofferdam had internal dimensions of 140ft by 70ft. As at Runcorn, the Widnes piers are founded on soft red sandstone, which forms the bed of the river, and are mainly of mass concrete. The main skewback pier contains 7500 tons of concrete.

Arch Superstructure

Some principal dimensions for the superstructure of the arch are given in the caption below the elevation. The chord members of the arch and side span trusses are of high-



Typical length of reinforced concrete approach viaduct on the Runcorn side

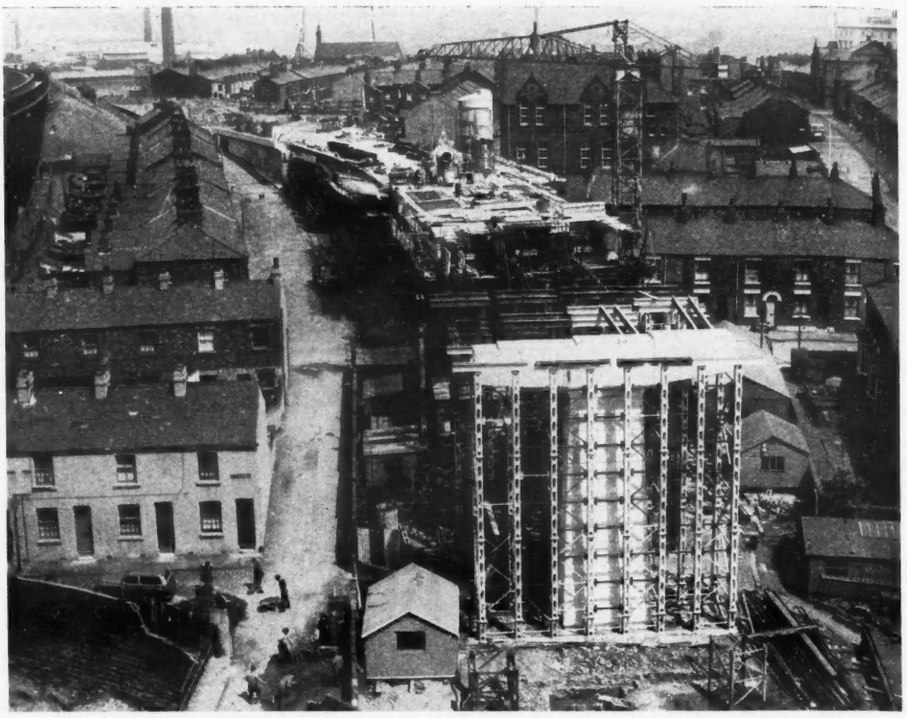
tensile steel and the other members are of normal mild steel. The trusses are of riveted construction. The loads from the arch are transferred to the foundations through 14in diameter forged steel pins.

The deck is to be suspended from the arch by locked coil wire ropes of 2¼in diameter. The cross girders and stringers are welded and are of high-tensile steel. The road and footpaths are of concrete cast *in-situ*. The roadway deck is 7½in thick and is surfaced with 2in of asphalt.

The total weight of steel in the main bridge is 5600 tons of which approximately 50 per cent is high-tensile steel. There are approximately 180,000 site rivets in the structure and some 5000ft of locked coil wire ropes are incorporated in the permanent suspenders.

At each end of the main structure there is an expansion joint of rubber in which a ring-shaped cross section deforms to take up the movements.

The bridge is designed following Ministry of Transport loading stipulations, including the abnormal indivisible load.



The Widnes approach under construction. The congested nature of the site is well brought out in this view

Erection

Erection is being carried out from both sides of the river, and is well shown in the illustrations on page 148. The design took account of a weight limit of 20 tons and a length limit of 70ft, for individual pieces of steel handled during erection. The erection sequence consists of (i) side span, (ii) the arch, (iii) suspenders and heavy deck steel, (iv) light deck steel.

Side Spans.—Erection commenced at the main bearings and the side spans were completed by working away from the river on both sides. The structure was supported on temporary trestles until the spans were completed and self-supporting, when the trestles were removed. On the Runcorn side erection was carried out using first a 20-ton derrick in a fixed position and subsequently a mobile crane of 25-ton capacity. On the Widnes side a 20-ton derrick of 100ft gabbards was first used; this derrick then erected a second derrick on the structure which completed the erection of the span.

On completion of the primary structure of the side spans, construction of the concrete deck was proceeded with, and kentledge consisting of tanks of water was placed on the side spans.

Arch. Erection of the arch on each side is being carried out by a "creeper crane," viz. a 20-ton derrick mounted on a purpose-made carriage on top of the arch. The carriage is on wheels which run on the top chord and allow the crane to be winched forward up the arch as erection proceeds. There is also an adjustable leg on the carriage which allows the derrick to be maintained in a horizontal position irrespective of the slope of the arch rib.

An additional derrick, mounted on the top of each side span, lifts material from the ground on to a bogie running on a track cantilevered out from the West top chord, and by extending the track as erection proceeds, material is transported to the creeper crane at the head of erection.

Erection has now reached the stage where it is necessary to anchor the cantilevered half arches to each bank. This is done by forestay cables attached to the upper chord and to the top of the temporary cable masts which are standing on the top chord. Backstay cables which are anchored in the rock at each side of the river are also connected to the top of the cable masts, where provision is made for jacking loads into the various cable lines.

When the two half arches are erected to the centre there will be a small gap of some 12in to 14in between the two halves. This will be closed by lowering out on the anchorage cables and jacking up at the tail-end of each side span, which has been erected lower than its final level for this purpose. When the closure is complete predetermined loads will be jacked into the upper and lower chords and all temporary anchorage material will be removed.

Suspenders and Heavy Deck Steel.—Suspenders, cross girders and the deck lateral bracing system will be erected by the creeper cranes as they are moved backwards down the arch to their original positions.

Light Deck Steel.—The erection of the remainder of the deck steel will be carried out by mobile cranes working forwards from both sides, travelling on the deck steel already erected. The concrete deck will be placed from both sides on the completed steelwork.

Firms Responsible for the Bridge

The consulting engineers for the bridge are Messrs. Mott, Hay and Anderson. The main contractor for the steel structure is Dorman Long (Bridge and Engineering), Ltd. The contractor for the foundations, who is also acting as sub-contractor for the concrete deck and approaches, is Leonard Fairclough, Ltd.

An Engineer's View of Planning City Centres

Last Friday the Civic Trust held a conference on "Rebuilding City Centres." Of the five points of view allotted to the principal speakers, only that of the civil engineer is given here in abstracts from the address "Engineering Aspects of Redevelopment," by Mr. R. Nicholas, city surveyor of Manchester.

IT is the traffic aspect of redevelopment which poses the question "What are our city centres to be designed for?" There are probably three distinct problems. The London problem as the largest, the problem of conurbation centres, such as Birmingham and Manchester, for example, and thirdly that relating to other larger town centres which are not in conurbations.

So far as London is concerned, I suggest that the problem is a different one because there is available there special transport facilities in tubes and suburban railways which will no doubt always survive the competition of the private motor-car as a means of commuting to and from work.

The existence of these facilities, in combination with the very heavy cost for land, buildings and business disruption, which would arise from a substantial provision of "freeways" extending into the heart of the Metropolis, will no doubt tend to restrict and limit their construction. The very size and capacity of the commercial area, however, is such that the use of the motor-car for business purposes would possibly be of exceptional value if the movement involved could be accommodated. So far as "freeways" are concerned, I have no doubt that away from the existing main urban roads in London there are vast areas of poor quality and even dilapidated property through which these could be constructed at far less cost than would be involved in the widening of existing roads.

On the other hand, in the conurbations most of the public transport system is confined to the use of the highway system. There are, of course, some suburban train services and in Glasgow a comparatively short length of Underground. In these areas the growth of traffic will in any case make it necessary to provide a considerable addition to the present highway system. It may well be found that the construction of two or three "freeways" to connect these areas with a National Motor Road system and perhaps one internal "freeway" ring road would drain so much traffic from the existing road system that it would be able to cope with the continuing growth of traffic for at least some few years to come.

In the third case of the other larger town centres, the effect of providing outer by-passes may relieve the central area congestion to a greater extent, because generally the smaller the town the larger is the proportion of traffic which is through traffic.

Future Requirements of Large City Centres

On the basis of an average of only one vehicle per family in this country, traffic will double itself within the next twenty years. On the basis of a continued improvement in the standard of living and progression towards that time to which I remember Lord Chandos referring in 1956 in the following terms: "It is not an impossible dream to say that the economical problem of man may be solved within the limits of this century. It is not an impossible thing to imagine that poverty and starvation may be historical facts which the generations to come will not need to emulate." On that basis it must surely be that people—ordinary people—will expect to enjoy the fullest use and convenience of the motor-car. With this thought in mind are we not entitled to ask ourselves whether we are thinking in proper terms about the city centre of to-morrow?

Looking at a plan indicating the age of buildings in the centre of a city such as Manchester, it is evident that such centres redevelop themselves about every 100 years. The rate of redevelopment may be more rapid in the future, but even so is not likely to take place so frequently that it can be easily organised in areas of complete clearing and rebuilding, or so that its layout can be changed to cope with conditions which may arise in a period of ten to twenty years. Therefore, we should attempt to look well ahead, and take any precautions which it would seem likely would enable us to deal with problems of the next generation, even though we can only now have somewhat indistinct ideas of what these problems may be.

I have no doubt that the needs to provide satisfactory working conditions for the black-coated worker will accelerate city centre redevelopment and it may well be that the need to provide parking facilities for his car will become increasingly important. In other words, commercial undertakings may be compelled to provide good working conditions and car parking facilities in order to attract office staff. I was interested to learn that in the new town of Crawley, in 1956 one industrial worker in ten used a car for travelling to and from work, while in 1958 the proportion had increased to one in seven and now is probably one in five. These figures are of considerable interest when one realises that these workers probably travelled only very short distances.

Returning to the city centre problem, there is of course a possibility that a greater use of the motor-car may lessen the need for commercial interest to collect together. May this not reduce the attractiveness of city centre sites and encourage commercial development in "district" or "suburban" centres?

Whether this happens or not, if we are to provide for a much greater use of the motor-car we have surely got to think in different terms to those we apply at the present time to calculate the car parking we require in new commercial buildings. In any case, the provision of independent basement car parks, many of them small and all of them having their own entrances and exits, hardly seems a satisfactory way of catering for more and more motor-cars. If underground parking is an answer to the problem, then probably it ought to extend over much larger areas without any respect for the boundaries of the sites within which the buildings above are placed.

May it not be desirable to think in entirely new terms of providing much of our city centre ground space for vehicular movement and parking which, of course, could be done by putting our buildings on stilts, and our pedestrian-ways at first floor level?

Obviously, there must be areas to which the vehicle should not be given access. These would form the open spaces and planted amenity areas and no doubt they could be largely connected together by pedestrian-ways at ground level, passing through and under the buildings above. Some instances of pedestrian access at ground level under buildings can be found in some foreign cities, and the movement through them and the constantly changing view can be most interesting and exciting.

Most of our urban centres are lacking in open space and amenity areas. Building higher, without substantially increasing the overall floor area, should enable us to provide a much larger proportion of floor space with good daylighting conditions and at the same time release the ground space.

So far as shopping areas are concerned, I am convinced, after seeing various New Town shopping centres, that we must plan for a complete segregation of pedestrian and vehicle in these areas. This can be done by converting our existing shopping streets into pedestrian-ways and providing service roads at the rear of the fronting premises, or even below them, or, of course, again it can in time be done by pedestrian access to shops at first floor level only.

Central shopping areas, where redevelopment covers a large proportion of the site and where a more or less constant height of building is obtainable, are also, of course, suitable for roof car parking. Even in the case of piecemeal redevelopment it would be possible to provide roof parks served by individual lifts. These roof parks could in the course of time be linked together.

When you reflect on the ideas about vehicle movement to which I have referred, it would seem possible to provide for their ultimate attainment by planning our new commercial buildings with ground and first floor heights which would enable the ground floor to be vacated as and when the need to use it for vehicular purposes could no longer be resisted.

Wherever these thoughts lead us, I am sure we would all agree that the proper use of existing materials and methods of construction can best be obtained by comprehensive redevelopment wherein really large building sites can be made available. I have not, of course, lost sight of the necessity for preventing or discouraging vehicles from entering our central areas unless they have business to do therein. One of the essential engineering aspects of central redevelopment is undoubtedly the provision of a ring road enveloping the city centre and round which traffic from the radial roads would travel in order to circumvent the centre or to find the nearest and most convenient entrance to their destination therein. On no account must our centres be split up and divided by continuing radial roads through them.

Nevertheless, if the motor-car is to become an every-day instrument of convenience, large numbers will move into and about the city centre for business and for travel to and from work. There must in any case be the largest possible separation of vehicles and pedestrians if only to reduce road accidents.

Apart from basement, surface and roof car parks there are, of course, other forms of "off-street" parking. The multi-storey garage is the most obvious one, but I believe that car parking at first and even second and third floor levels over a whole site, with an office building above on slab or tower block formation, has great possibilities. We hope to have such a composite building in Manchester in the very near future.

Pharmaceutical Plant at Hoddesdon

THERE has been completed recently at the pharmaceutical factory of Merck Sharp and Dohme, Ltd., at Hoddesdon, the first stage of a ten-year expansion programme. This first stage consists of a three-storey building, which can be seen in our illustration, measuring 200ft by 160ft by 55ft high, the construction of which presented certain difficulties since it was essential to carry out the work with the minimum of inconvenience and in the minimum of time. Before building could commence a considerable amount of site work was involved, including demolition, and this, combined with the restrictions imposed by the confined site area, decided that the framework should be in precast concrete. To achieve the site it was necessary to demolish and rebuild an Electricity Board substation, to remove other buildings, and to construct a heavy retaining wall below the Hertford Road, in order to provide a new access road.

A three-storey design was adopted so that there would be a gravity flow of materials from the manufacturing area arranged on the top floor, allied with simple administrative and analytical control and economic and flexible services. The upper floor storey heights adopted permit trunking and main services to pass across the building above a suspended ceiling while the height of the ground floor space allows for the stacking of palleted materials to the maximum height and the unloading of lorries by fork lift trucks. A column grid of 40ft by 20ft was adopted as the most economical floor span and the floors were designed to carry a live load of 200 lb per square foot. Except for air-conditioned spaces there are no internal partitions, so that there are clear areas totalling about 70,000 square feet and providing for great flexibility in operation of plant.

Due to a rise in the level of the water table, it was found that normal pressure foundations could not be used, so that bored piling to a depth of 25ft was required for the main building. Similar piling to a general depth of 40ft supports the Hertford Road embankment. This work was carried out by the Cementation Company, Ltd. The columns were constructed in one length with provision for setting the beams at their various levels, while the main beams had haunches added at each end to provide additional shear and to reduce stresses at the junctions with the columns. Although precast reinforced concrete units, supplied by the Concrete Development Company, Ltd., were used for the structural frame, *in situ* concrete was employed for the two 60ft span portal beams over the loading bays. Also constructed *in situ* were the two lift shafts and the two stair towers which serve as rigid stabilisers for the building frame. Reinforced concrete cast *in situ* between precast reinforced secondary beams was used for the floors and for lightness the roof was constructed of hollow " Raphcon " slabs with compression areas at the main beams of *in situ* concrete. The structural grid adopted enabled 5ft standard spacing for the window walling mullion to be used. Space for expansion has been taken into consideration: although the first stage of development is complete in itself the curtain walling on the south side is removable and provision has been made for the services to incorporate an extension building of similar size.

The mechanical services, which are generally adequate to serve the present building and the planned extension, consist of two G.W.B. boilers, each rated at 5175 lb per hour at 100 lb per square inch, and associated Permutit ion-exchange water softening plant. Oil fuel of 950 deg. Redwood scale is stored in two 7000-gallon capacity tanks, and space is available for an additional tank and for a third boiler. Air at 100 lb per square inch is supplied to two receivers by two Broomwade single-stage compressors, each delivering 100 cubic feet per minute. Two Lacey Hulbert, twin-cylinder, air-cooled vacuum pumps are installed, each having a displacement of 100 cubic feet per minute of free air to 28in Hg. For refrigeration requirements there are two sets of York Shipley equipment, using Freon 12 refrigerant, including an economiser, condenser and a multi-pass shell and tube evaporator. There are three 350-gallon hot water storage calorifiers and a heating calorifier for the office block. All the pumps for the various services are of Holden and Brooke manufacture. Within the building, heating is by thirteen units, consisting of an Aerofoil fan, steam heater battery and dampers, and capable of providing up to six air changes per hour. There are four air-conditioning units, each of which has been purpose made. One unit serves the first floor packaging area, having internal conditions of 70 deg. Fah. dry bulb and 30 per cent relative humidity. The remaining units serve the second floor; one, using 100 per cent fresh air, being allocated to the sterile room which has absolute filtration and ultra violet irradiation to reduce bacterial count. The internal conditions are 75 deg. Fah. dry bulb and 51 per cent relative humidity. The third and fourth units each serve spaces having internal conditions of 68 deg. Fah. dry bulb and 40 per cent relative humidity.

Electrical power is delivered to the substation, where there are two B.T.H. 11,000V circuit breakers, at 11,000V, and two 500kVA 11,000/V 433V transformers feed two medium-voltage switchboards. Provision has been made to receive a further supply from a third transformer so as to provide, if required, a capacity of 1500kVA. The level of illumination on the ground and second floors is 25 lumens per square foot and on the first floor is 35 lumens per square foot. On the second floor are arranged the tablet compressing and coating sections, and the sterile filling department, equipped with one steam and one high-temperature electric steriliser, where liquids for injection are sterilised by filtration and operations are carried out under aseptic conditions. In the non-sterile area pyrogen-free water is prepared and elsewhere on the floor is a demineralisation plant, a lozenge manufacturing and packaging section, liquid medicine production equipment, an ointment manufacturing area and a section in which the tablet materials are prepared, the equipment including mills, dry and wet mixers and hot-air ovens. On the first floor is an air-conditioned packaging area in which temperature and humidity are specially controlled to ensure that products do not absorb moisture. There is a liquid filling line and an ointment filling and packaging line, together with a loading area for pallets which are handled by fork lift trucks and then transferred by lift to the ground floor. Here is the shipping area, the boiler house and plant room, also the microbiological laboratory and media kitchen, and the physical and chemical laboratories. The distribution piping on each floor is a modified ring main system with capped outlets at 16ft intervals to allow for flexibility and expansion of the various processes. The mains have been sized and provided with capped outlets to link with the next building phase.

The architects were Edward D. Mills and Partners, the consulting engineers were J. C. Hughes and Partners, and the quantity surveyors were Leslie W. Clark and Partners. Holland & Hannen and Cubitts (Great Britain), Ltd., were the main contractors, and Engineering Service Installations, Ltd., provided the mechanical services.

Pharmaceutical plant at Hoddesdon

Technical Reports

The Radioactivity of the Atmosphere Near Ground Level Due to Distant Nuclear Test Explosions. (A.E.R.E.—M620.) By D. H. Peirson, R. N. Crooks and E. M. R. Fisher (A.E.R.E., Harwell). H.M. Stationery Office. Price 1s. 9d.—In parallel with the A.E.R.E. programme of analysis of rainwater for fission products (reports A.E.R.E. HP/R2354 and A.E.R.E. HP/R2790) samples of dust have been collected from the atmosphere at a height of about 1in above ground level at Chilton, Berks. The results, up to 1955, of the measurement of total beta activity have been discussed in report A.E.R.E. HP/R2017. The report now under review precedes a comprehensive report on the results of the analysis of samples collected at various heights in the atmosphere, up to 15 km. Tables and graphs in the report show the total beta activity and the caesium-137 content of these samples from 1953 to March, 1960, and the zirconium-95 content from August, 1957, to March, 1960. The caesium-137 content shows a seasonal variation similar to that found previously in strontium-90 in rainwater. The monthly concentration of caesium-137 activity rose to a peak of 10^{-13} μc per cubic centimetre in May, 1959. The corresponding values derived for strontium-90 and plutonium-239 were 7×10^{-14} and 10^{-15} μc per cubic centimetre, respectively.

Errors Due to Cylindrical Cell Approximation in Lattice Calculations (A.E.E.W.-R34). By D. A. Newmarch (U.K.A.E.A. Research Group, Winfrith) H.M. Stationery Office. Price 3s.—It is shown that serious errors in fine structure calculations may arise through the use of the cylindrical cell approximation together with transport theory methods. The effect of this approximation is to overestimate the ratio of the flux in the moderator to the flux in the fuel.

It is demonstrated that the use of the cylindrical cell approximation gives a flux in the moderator which is considerably higher than in the fuel, even when the cell dimensions in units of mean free path tend to zero; whereas, for the case of real cells (e.g. square or hexagonal), the flux ratio must tend to unity.

It is also shown that, for cylindrical cells of any size, the ratio of the flux in the moderator to flux in the fuel tends to infinity as the total neutron cross section in the moderator tends to zero; whereas the ratio remains finite for real cells.

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Summer School in Electrical Engineering

THE fourth Summer School in Electrical Engineering for university lecturers was held by Associated Electrical Industries, Ltd., at Rugby, from July 11 to 15. Programmes of lectures were arranged in the mornings, and in the afternoons visits were made to the new research laboratory at Rugby, the development laboratories of the Electronic Apparatus Division at New Parks, Leicester, and the Rugby works. Social activities included a visit to the Shakespeare Memorial Theatre, Stratford-on-Avon, on July 13, for a performance of "Twelfth Night."

Considerable attention was given to semiconductor devices in the course of the lecture programme, the aspects dealt with being silicon diffused power transistors, microwave devices, silicon controlled rectifiers and static switching. In dealing with the last named subject, Mr. G. T. Ohlsen showed slides of recently developed transistorised memory and time delay units, and of a 75W transistor amplifier.

During the visit to the New Parks laboratories, visitors saw demonstrations of industrial remote control and warning systems making use of audio tones. Work is also proceeding on inductive communication systems, and an all-transistor unit was shown for inductive loop control of mobile overhead cranes from a ground level station, using five tones, individually for selecting the various motions and combining them in different ways for speed control. Another exhibit was the A.E.I. system for position control of a milling or boring machine by means of magnetic tape. Plan sheet information is first converted into punched tape form, and the punched tape is then processed in a general purpose computer, giving an output on magnetic tape. Among the service control exhibits was a system for control of a rotatable radar aerial which limited deflection in a 40 knot wind with 60 knot gusts to one minute of aerial movement. Several demonstrations related to nuclear engineering, among them being a method for the operation of reactor control rods using transistor circuits throughout, transistors being now fully accepted for rod control systems. Industrial speed control systems seen at the laboratory included a silicon rectifier circuit comprising a bridge with controlled rectifiers in two arms, and a transistor amplifier for controlling the firing points. This arrangement controlled a 1 h.p. motor and provided a speed range of 30 or 40 to 1. Transistor amplifiers are being developed for use in conjunction with germanium rectifiers in sectional drives for newsprint machines and in unit drives for rotary printing presses; silicon rectifier schemes incorporating saturable reactors are being studied for automatic speed setting and control as alternatives to grid-controlled, single-anode mercury arc rectifiers. A further application of silicon controlled rectifiers was seen in an inverter unit for railing vehicle fluorescent lighting on a supply of 110V d.c. Here the rectifiers are controlled by a low-power transistor oscillator and an a.c. output of 250V, 1200 c/s is obtained.

On the two final days at the school the lecturing subjects included the A.E.I. turbo-electric propulsion equipment for the P. & O. liner "Canberra," a reversing rolling mill drive using mercury-arc converters operating both for rectification and inversion, new thermal methods of measuring iron loss in machines, computers and the machine designer, and aircraft electrical power systems. The paper on the liner "Canberra," by Mr. L. W. W. Graham, also illustrated a suggested layout for a five-screw ship taking advantage of the latitude in positioning the power plant allowed by an electric drive. Mr. P. Watkins' paper (read by Mr. A. M. Plaskett) on the rolling mill drive gave details of an installation in which a 4000 h.p. reversing motor is supplied at from 0–900V d.c. by a twelve-phase rectifier system of ten six-anode valves, with regeneration to allow rapid deceleration and reversal.

Computer Conference in Harrogate

THE second annual national conference of the British Computer Society, Ltd., was held in Harrogate from July 4 to 7. In his opening address the President of the Society, Dr. M. V. Wilkes, F.R.S., announced that the society, representing the United Kingdom, was one of fifteen computing associations which would participate in the Second International Conference on Information Processing in 1962. Referring to the work of the Society's committees, he suggested that attention might be turned to the problems of data transmission, and outlined the concept of dialling a computer centre on the ordinary telephone system and then transmitting data for computation.

At the session on a common language for computers, Mr. R. A. Brooker, of Manchester University, described a "do-it-yourself" autocode based on the use of basic expressions and procedures which a computer could analyse and translate into a language to suit its own particular characteristics. Mr. R. M. Paine, of International Computers and Tabulators, Ltd., emphasised the difficulty in the commercial users' field in defining initially, in ordinary English, the procedures which the machine was expected to operate. He suggested that the high cost of programming, put by some people as equal to the cost of the computer itself, was probably mainly due to the need to make a very detailed, and often costly, organisation and methods study of the problem before a start could be made with any automatic programming system.

Market research was discussed in the third session, in the course of which Mr. J. A. Gosden gave examples of market research done by J. Lyons and Co., Ltd. By classifying retail shops according to the size of their ice-cream cabinets and the frequency with which the delivery vans called on them, the computer was able to tell the firm which retailers were not using their cabinets properly, and also to suggest ways of re-routing the vans in order to reduce distribution costs. A computer could also be used to check that the answers given by market research interviewees were not "impossible." Techniques of this kind were described by Mr. R. L. Cook, of Elliott Brothers (London), Ltd.

Subjects dealt with at other sessions of the conference included the state of the art abroad, simulation studies in process control and planing, and large-scale data processing in Government departments.

British Commonwealth Scientific Committee

THE British Commonwealth Scientific Committee, under the chairmanship of Sir Harry Melville, F.R.S., secretary of the Department of Scientific and Industrial Research, has just concluded a two-weeks conference at Henley. The committee has held several formal and informal meetings during a tour of Britain which took it on many visits to research establishments in industry and Government organisations. A statement about the proceedings says that many matters of considerable importance have been discussed and the result, generally, is a closer link between all the countries of the Commonwealth. Already, through the British Commonwealth Scientific offices in London and Washington, there exists the machinery for full co-operation and the Committee has extended to the newly emerged and emerging countries of the Commonwealth the use of these facilities. In addition, immediately on gaining independence, a new Commonwealth country will be invited to participate in the work of the Committee. The committee has welcomed Malaya's decision to be represented in the British Commonwealth office in London and also Ghana's intention to do so as soon as staff becomes available.

There is to be close collaboration in the translation of foreign-language scientific and technical literature, especially from Russia and other Eastern countries. This will prevent unnecessary duplication of the translation work of the United Kingdom National Lending Library for Science and Technology and the co-operative exchange with the corresponding United States translation centres, and thus free the resources in the Commonwealth to carry out translations not covered otherwise. The committee is also sponsoring a survey of "high-class" technological abstracting to assess the general adequacy of abstracts in the various fields of technology. In the special fields of oceanography, antarctic research, air pollution control and astronomy it was decided to take no specific action as the existing international arrangements are quite adequate, with the Commonwealth already playing a full part in them. At the same time the committee unanimously agreed that it was of immediate importance to develop and expand scientific effort on pure and applied research into the production of food, the improvement of health, the exploitation of mineral resources and industrial development, which are vital to the well-being of the Commonwealth and indeed the whole world. It was stressed that with so many new fields of research developing, such as the exploration of space, it was doubly important not to lose sight of those things which are essential to improved standards of living. Therefore, research in the medical, agricultural and industrial spheres should at all times receive a full measure of support. An important development is the formation of a Commonwealth Committee on mineral processing and the British Commonwealth Scientific Committee recognises the importance of helping the younger independent nations in this type of co-operative research.

Dungeness Nuclear Power Station

THE Central Electricity Generating Board has announced its intention to place a contract for the building of a nuclear power station at Dungeness, Kent, with the Nuclear Power Group (which includes Associated Electrical Industries, Ltd., Clarke, Chapman and Co., Ltd., Alex. Findlay and Co., Ltd., Head, Wrightson and Co., Ltd., Sir Robert McAlpine and Sons, Ltd., C. A. Parsons and Co., Ltd., A. Reyrolle and Co., Ltd., Strachan and Henshaw, Ltd., John Thompson, Ltd., and Whessoe, Ltd.). This station, which will have an output capacity of 550MW, is scheduled to come into operation in 1964.

The site (about 112 acres) is on the western side of the Dungeness point, and is close to deep water in the English Channel. As the area is of considerable interest to naturalists and physiographists, special arrangements have been made by the Generating Board to minimise any disturbance to the natural life and surface features of the area. The land which has been purchased by the Generating Board is of shingle and has no agricultural value. Circulating water (about 21,250,000 gallons per hour) will be taken from, and returned to, the English Channel.

The station will contain two gas-cooled, graphite-moderated, natural uranium fuel reactors operating on the same principle as those for the stations already being built for the Generating Board, but with current technical

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improvements. Each reactor will have a prism-shaped, graphite core, made up of large octagonal and small square bricks, enclosed in a spherical steel pressure vessel. The vessel will be surrounded by a primary biological shield of concrete through which pass the gas ducts to four boilers. Dry carbon dioxide at a pressure of 283 lb per square inch absolute will be circulated between the reactor core and the boilers by four blowers driven by back-pressure steam turbines. Each reactor unit will have its own control system, fuel store, on-load fuelling equipment and fuel cooling pond. A " Goliath " crane of 400 tons lifting capacity will be used to transfer both light and heavy parts of the reactor plant from the construction or delivery areas into the reactor areas. Heavy parts to be lifted include boilers, pressure vessel segments, &c.

Technical Data, Dungeness Nuclear Power Station

Performance :	
Net electrical output	550MW
Heat output per reactor	835MW
Efficiency	32·9 per cent
Reactor gas bulk outlet temperature	410 deg. Cent.
Reactor gas inlet temperature	250 deg. Cent.
Nominal maximum can surface temperature	442 deg. Cent.
Nominal maximum uranium temperature	563 deg. Cent.
H.P. steam pressure at blower T.S.V.	1410 p.s.i.a.
H.P. steam temperature at blower T.S.V.	392 deg. Cent.
H.P. steam output	407,000 lb/hr.
L.P. steam pressure at main T.S.V.	550 p.s.i.a.
L.P. steam temperature at main T.S.V.	391 deg. Cent.
L.P. steam output	271,000 lb/hr.
Feedwater temperature	180 deg. Cent.
Fuel :	
Number of fuel channels per reactor	3876
Number of elements per channel	Seven
Overall length of fuel element	41·7in
Dimensions of uranium rod	37·6in by 1·10in. dia.
Total weight of uranium per reactor	298 tonnes
Core Dimensions :	
Diameter of active core	45ft 4½in
Height of active core	24ft
Diameter of reflector	50ft
Height of reflector	27ft 10in
Lattice (square) pitch	7·75in
Gas Circuit :	
Mean diameter of reactor vessel	62ft 6in
Reactor vessel general thickness	4in
Gas working pressure	283 p.s.i.a.
Number of gas circuits per reactor	Four
Diameter of gas ducts	6ft 6in
Power input per blower	7MW
Overall height of boilers	75ft
Internal diameter of boilers	23ft 6in
Shell thickness (graded)	3½in to 2⅛in
Turbo-Alternators :	
Number of main turbo-alternators	Four
Continuous maximum rating per set	142·5MW
Speed	1500 r.p.m.
Generator voltage	13·8kV
Vacuum	28·9in Hg.
Exhaust wetness	14·3 per cent
Total circulating water quantity	353,000 g.p.m.

The turbine house will contain four 142·5MW turbo-alternators. The steam and electrical connections between reactor units and turbine house will be taken underground through tunnels. The steam will be generated in the boilers at two pressures, 1418 lb and 590 lb per square inch absolute. All the higher pressure steam will be passed through the back pressure turbines driving the blowers. These turbines will exhaust at the l.p. pressure and, after reheating in the boilers, this steam will be passed with the l.p. steam to supply the main turbines. The overall station efficiency when working at these conditions will be 32·9 per cent.

The station will be connected to the 275kV supergrid.

Cross-Channel Power Cable

THE Central Electricity Generating Board has placed a contract worth about £600,000 with Associated Electrical Industries, Ltd., and British Insulated Callender's Cables, Ltd., for cables to be used for the cross-Channel power link between England and France. The contract covers the English shore section and one-half of the Channel connection. The remainder will be made by French cablemaking companies working on behalf of Electricité de France. Two similar 15 mile lengths of single-core submarine cable will be used for the " go and return " circuits.

As the cables must be laid close enough to one another to conform with the Minister of Transport's requirement that at all times the magnetic compass deflection caused by the cables does not exceed 2 deg. at the sea surface, special techniques have been devised for laying both cables simultaneously. The Generating Board's collier, the motor-ship " Dame Caroline Haslett," has already been used for cable-laying trials, and will be also used for the actual cable-laying operation due to take place in the summer of 1961.

The connection between the 275kV supergrid in this country and the 225kV French network will be by a d.c. circuit of 160MW, with a 20 per cent overload for isolated periods of thirty minutes. The d.c. transmission will operate at 200kV between poles, with its centre point earthed, and the cables will be insulated for a nominal voltage of 100kV to earth. The normal full load current will be 800A. When complete, this submarine circuit will carry the heaviest d.c. load ever transmitted under water.

The Channel connection will consist of two 30-mile submarine cables routed between a point near Dungeness, Kent, and Le Portel, a suburb of Boulogne, with 3-mile to 4-mile sections of land cable at each end. Converter stations able to rectify from alternating current to direct current and invert from direct current to alternating current are to be sited at Lydd, in Kent—where connection will be made to the British grid system through a 275V line to Canterbury—and at Echinghen near Boulogne. The d.c. circuit will go via underground cable from Lydd to a link-house at Dungeness. The circuit will also join the French 225kV grid system by underground cable from the coast, at Le Portel, to the converter station at Echinghen. The depth of the Channel over the British half of the route reaches a maximum of 20 fathoms, while the maximum in the French half is about 30 fathoms.

The cables themselves, as developed successfully from the sea trials, are of the impregnated paper insulated solid type. The submarine cable conductor is of 0·525 square inch in cross section and consists of stranded copper wire lapped with an electrostatic screen. The solid type impregnated paper insulation, also lapped externally with an electrostatic screen, is sheathed with lead alloy " E " which is protected against corrosion by vulcanised rubber tapes. Armouring is provided by a single layer of 0·232in galvanised steel wires with appropriate beddings and servings. The cables weigh about 39 lb per yard in air and about 28 lb per yard in sea-water.

Anti-twist tapes will be applied over the lead sheath and under the anti-corrosion protection, these tapes being necessary to ensure that the cable is not damaged under the excessive tensions that may be required to lift the cable out of the sand on the sea bed during recovery after a possible fault. The design stress of these cables is about 150kV per centimetre at ambient temperature.

The inferior heat dissipating properties of the soil compared with those of the sea necessitate using a larger conductor size for the land cable. Over sections of the route where the normal type of loam is found a conductor size of 0·6 square inch will be employed but, in the shingle areas which have very poor thermal dissipation properties, a 0·925 square inch conductor will be necessary.

The land cable will be similar in design to the submarine cable, except that neither anti-twist tapes nor submarine anti-corrosion protection will be used, and the armour wires will be considerably smaller. The section of land cable from the link-house will, however, be joined to the submarine cable below high water mark for thermal reasons, and will therefore include anti-corrosion protection and have armour wires of the same size. Each country will be responsible for its own land section and half of the submarine section, from the coast to mid-Channel, where the cables will be joined together.

Work has already begun on the construction of the Lydd converter station and by 1961, when the manufacture and laying of the submarine and land cables will have been completed, a new reserve of power will be obtainable economically in these two countries which are great industrial and domestic consumers of electricity.

It is estimated that the cost of manufacturing and installing the d.c. cables and associated equipment will be about £4,600,000. Against this outlay there will be available to Britain at times of peak demand the equivalent of generating plant capacity which, if it had to be installed, would cost some £8,000,000. The cross-Channel interconnection is expected to result in net annual savings to this country of £250,000.

Vibratory Hopper

AN electronic attachment replacing methods of mechanical orientation of components has been developed for a new vibratory component feeding hopper introduced by W. R. Hamilton (Plymouth), Ltd., Tavistock, Devon. The hopper is operated by a heavy-duty armature, rotation of which is adjusted by a lever. The accompanying illustration shows the aperture in the side wall through which the lever extends, and the thumb nut by which it is locked at the desired position. In the rare cases where the component feed rate is outside the range of the setting lever, further control is possible by adjustment of the gap between the armature and the pole pieces.

Electro-mechanical hopper for feeding small components. An electronic attachment can be fitted for returning those which are incorrectly orientated on reaching the feed point

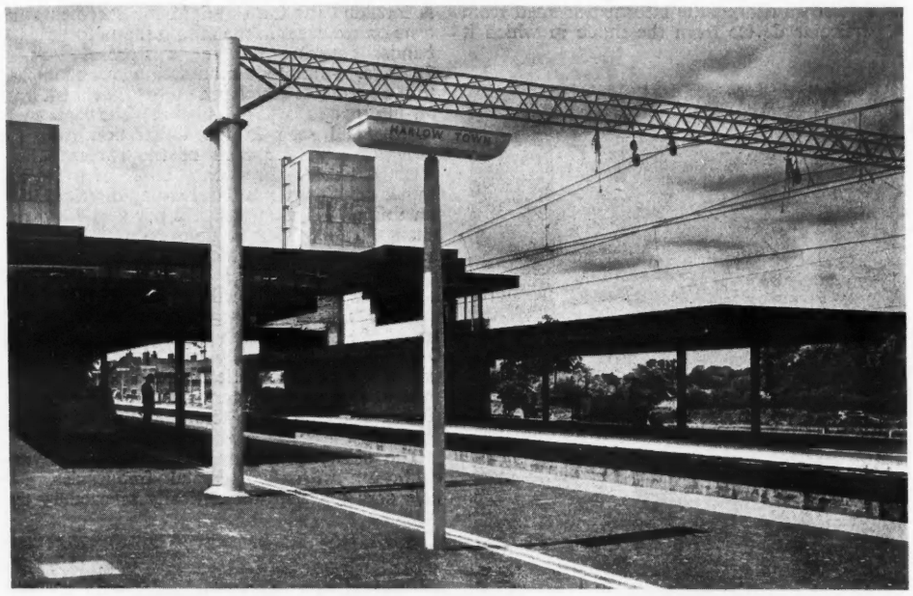
Standard bowls of 12in and 18in diameter are available, but a variety of shapes and sizes can be provided to meet individual needs.

The electronic orientation attachment operates through a sensing block and probe which may be clamped to the bowl near the delivery point. The block is shaped so that objects travelling in the required manner pass over the probe without touching it. If a part is reversed, however, it depresses the probe into contact with the block and completes the input circuit to an electronic amplifier. This has the effect of energising a solenoid and the component is pushed back into the bowl.

[Reply Card No. E1542]

Harlow Town Station

THE first new station to be built in this country specially to serve the needs of a new town was officially opened at Harlow, on the Great Eastern line of British Railways, on July 13. It replaces the small station, built in the 1840s, and known as Burnt Mill. Work was started eighteen months ago when the old buildings were gradually demolished to make way for the new which extend a few hundred yards north. The site, which occupies 4 acres, is in low-lying marshy ground, so that an initial part of the task was satisfactory draining. About 300 piles had to be driven to carry the new station, some to a depth of 25ft.



The new station occupies a site of 4 acres. The buildings are dominated by 50ft lift towers as shown in the background of this picture

The new station is approached by a short access road leading directly off the Harlow Town's ring road. Passengers enter through a glass-walled concourse, 50ft wide, 40ft deep and 17ft high, around which are the fully-mechanised ticket office, public telephones and station master's office. The inquiry and parcels office and large parcels yard are on the east side, while on the west is storage for 150 bicycles under cover. The station is equipped with automatic train departure indicators and a public address system. The concourse gives access to two island platforms by stairways to and from the overbridge, on which are situated the public and staff amenities.

A transistorised crystal chronometer, the first to be used in the Eastern Region, has been installed on the station. It employs fifty-three transistors and controls eleven " slave " clocks, being accurate to within half a second a week. The conventional pendulum action is replaced by a crystal oscillator, the frequency of which is divided to produce an accurate time source, to give half-minute impulses. The master clock will also be used to control those to be installed in the Harlow Mill goods depot, 1¾ miles down the line.

The station is so planned that parcels and packages are not handled in areas used by passengers. The entire parcels traffic is conveyed between platforms by three lifts, with 50ft towers. The overbridge deck is constructed of prestressed concrete units which rest on reinforced concrete bearings, cantilevered from the lift shafts. This allowed the bridge to be built with the minimum interference to trains. The concourse roof is supported by a concealed framework of prestressed concrete beams cantilevered from four pre-stressed columns. Staircases are of reinforced concrete on load-bearing brickwork. The parcels office, cycle store, overbridge roof and platform canopies and shelters are steel-framed with timber beams. The lift towers, two of which may be seen in our illustration, are all of reinforced concrete construction. The station roofs are covered with three-layer felt on timber boarding.

Simultaneously with the construction of the station has gone the installation of a new track layout. There are now four lines through the station, instead of two ; an up and down main line and loops in each direction. The latter can be extended to form carriage sidings if required. Also on the up track is a siding for dealing with parcels, newspapers and similar traffic. The new track layout has meant extensive signalling alterations. Semaphore signalling is replaced by " searchlight " colour-light signals, controlled by a new signalbox at Harlow Mill, which houses the route-setting control panel for the whole area. The former signalboxes of Burnt Mill and Harlow are no longer required.

A new bridge on the west side of the station carries a by-pass road over the railway. It has been built by British Railways for the county authorities and has enabled the former Burnt Mill level crossing to be closed. The architect for the new station was Mr. H. H. Powell, F.R.I.B.A., Eastern Region of British Railways, and the work was carried out under the general direction of Mr. A. K. Terris, M.I.C.E., chief civil engineer, Eastern Region, the main contractor being W. and C. French, Ltd. The construction of the new station has been undertaken at the same time as work necessary for the introduction, in November, of the electric train services between Bishops Stortford and Liverpool Street.

Control For Pneumatic Rams

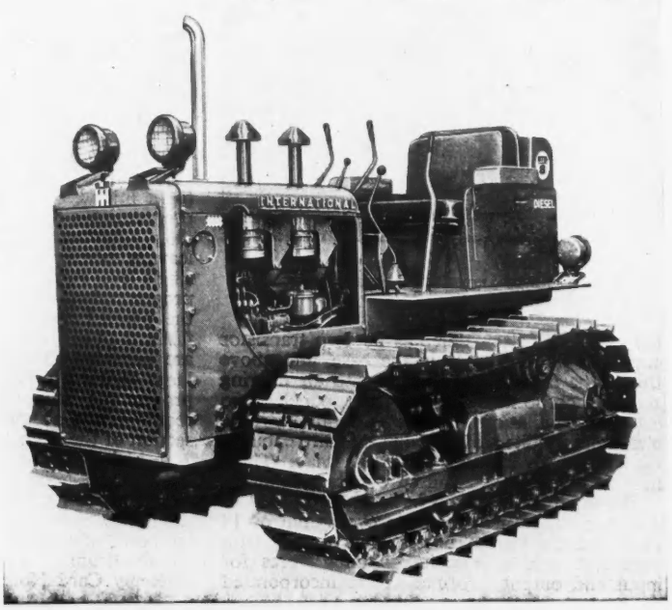
THERE has been announced by T.A.L. Numatics, Ltd., Leighton Buzzard, Bedfordshire, a system of controlling a double-acting pneumatic ram that allows it to be inched through its travel. The two ends of the cylinder are connected to a valve of the " 34 " series, so that both ends are normally open to supply pressure, but either one can be switched to exhaust. The valve is self-centred by air pressure, and hence can be controlled by subsidiary air valves, but solenoid operation is optional; an advantage of using air operation only is that, by feeding the self-centring volumes from upstream of the non-return valves, the control circuit can be arranged to become inoperative if the air supply fails, so that the ram is in effect locked.

[Reply Card No. E1552]

60 H.P. Crawler Tractor

AT the recent Royal Show at Cambridge, the first production model of a new crawler tractor was exhibited by International Harvester Company of Great Britain, Ltd., 259, City Road, London, E.C.1. The tractor, which is illustrated herewith, is designated BTD–8 (80 series). It is fitted with an " International " four-cylinder diesel engine, designed to develop 60 b.h.p. at a governed speed of 1600 r.p.m., the maximum torque being 225 lb ft at 1100 r.p.m. As with other International engines, there is electric " glowplug " starting. A choice of two transmissions is offered, one with five forward and one reverse speeds and the other permitting four forward and two reverse speeds. The five forward speed arrangement gives a range between 1·8 and 5·4 m.p.h. The width of the standard track shoes (there are thirty-one on each side) is 14in, the length of track on the ground being 5ft 3½in. Some new features in the transmission, according to the makers, include the use of 30 deg. angled spiral bevel gears to give extra mesh and a flexible coupling in the drive line which absorbs shock loads from the track sprockets. The 10⅞in diameter multi-plate steering clutches have sintered-metal facings. The comfort of the operator has not been overlooked in designing the tractor; there is adequate leg room and the high-backed seat is adjustable to four positions. The drawbar pull is calculated at 11,000 lb in first gear.

[Reply Card No. E1553]



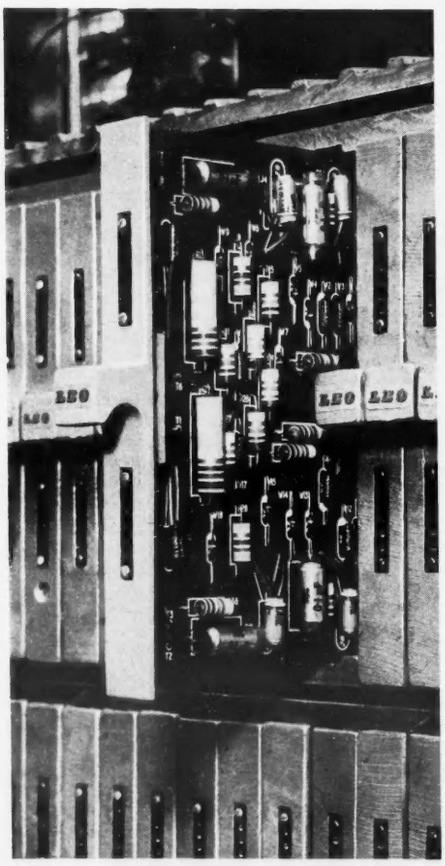
The BTD-8 crawler tractor is powered by a four-cylinder diesel engine designed to develop 60 b.h.p.

SHORTER REPORTS *(Continued)*

Advanced Data Processing

BASED on experience accumulated since 1947 from previous computers in the " Leo " series, a new data processing system known as " Leo III " is under construction by Leo Computers, Ltd., Hartree House, Queensway, London, W.2. This all-transistor computer in its prototype form was inspected last week at the company's Acton factory. It is built up with printed circuit packages as seen in one of the accompanying illustrations and embodies as a salient feature the principle of microprogramming, whereby a mathematical operation involving numerous steps may be initiated by a single programme instruction to one of the magnetic core planes (illustrated) forming the microprogramme control. For each action that is available to the programmer there is one such plane, and the computer carries out, step by step, a series of elementary operations indicated by the plane.

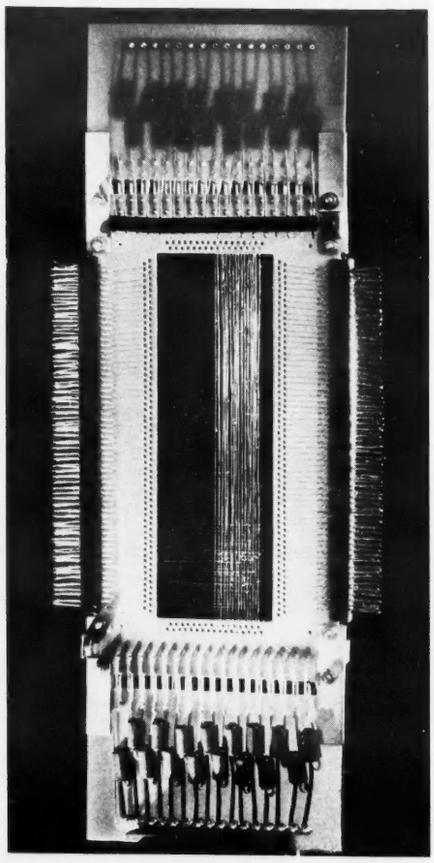
In order to allow full advantage to be taken of the space-saving made possible by transistor circuits and magnetic core storage, the circulation of cooling air is fan-assisted and in consequence the circuit packages can be closely packed in



Circuit packages in position in computer cabinet

the cabinets. Each unit has its own transistor stabilised power supply in the base, and above this is the fan ventilating unit with air filtering screen incorporated in the front panel. No external ventilation ducting is required. The electronic circuits are housed in standard cabinets 6ft 6in high by 2ft deep by 2ft 6in wide. These may be disposed as required by site conditions.

The main storage is in basic units of 1000 or 4096 words, with a complete cycle time of 14 microseconds via an access control unit with automatic priority circuits. Buffer stores for input and output information are incorporated in the main store. The system will work in a wide range of units and no programmed conversion of numbers from one form to another is needed when information is read in or the results recorded. Input and output devices are linked to the main computer through " assemblers," each in its own cabinet or cabinets. An input assembler transforms the information read from a particular device from the mode in which it



Magnetic core plane for computer microprogramming control

works into the mode in which the main computer works. Similarly, results sent out to an output device are transformed from the mode of the computer to that of the device. Thus, when a new input or output device is required to be linked to the computer, the only change involved is the introduction or substitution of the appropriate assembler.

There is a facility enabling several programmes to be interleaved under the control of a master programme which allots priorities and relieves the programmer of the need for considering interleaving when writing his programmes. The single-level store is a further contribution to easy programming. The arithmetic unit, operating in the parallel mode, is some eight to ten times faster than the one in " Leo II." Three displays are provided to assist operators, comprising a large digital display indicating the nature of a programme stoppage, a print-out of action required, and a monitor tube for examining any section of the store.

A high-speed printer available as an output medium embodies a printing drum and electronically timed hammers which strike the paper at the appropriate instant to make the impression by means of a printing ribbon between the paper and the drum.

[Reply Card No. E1561]

Standard Signal Generator

CLARITY of indication and convenience for the operator are qualities to which particular attention has been given in designing the TF144H standard signal generator of Marconi Instruments, Ltd., St. Albans, Herts. The instrument is intended for the standard measurements and tests on receivers in the m.f., h.f. and lower v.h.f. bands, covering the range from 10 kc/s to 72 Mc/s. Amplitude modulation can be applied to the carrier at any depth up to 80 per cent from an internal or external source. The large main tuning dial seen in the illustration carries a separate scale for each of the twelve switch-selected bands. Frequency cover of a band is rather more than 2:1. The reading discrimination on this dial is such that a 2 per cent frequency change on any band occupies more than a $\frac{1}{4}$in of scale length. The instrument is also fitted with an electrically-coupled incremental frequency control calibrated directly in per cent frequency change. This control covers 1 per cent and has a travel of 315 deg. With it, frequency changes of 0·01 per cent can easily be discriminated. Full use of this characteristic is possible, because the instrument has a good frequency stability (0·002 per cent in a ten-minute interval after warm-up).

The signal generator has a built-in crystal calibrator with two crystal frequencies, 400 kc/s and 2 Mc/s, automatically selected by the

Signal generator for standard tests on receivers for m.f., h.f. and the lower v.h.f. bands

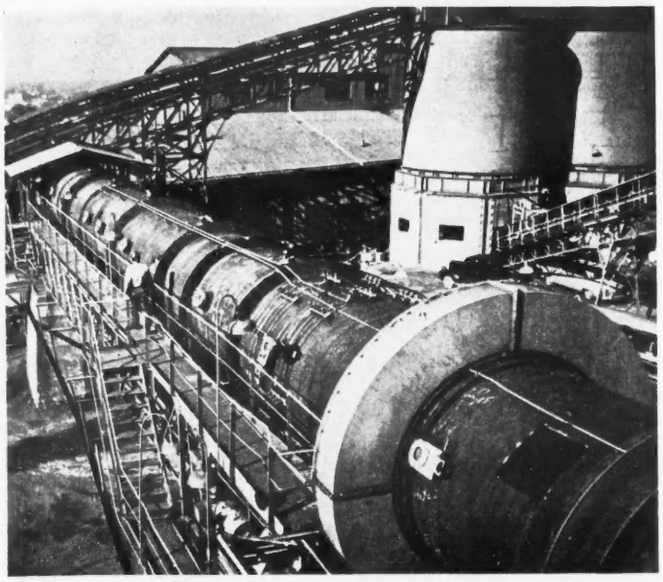
band-change switch. Output level is variable over the range of 2μV to 2V by means of coarse and fine resistive step attenuators calibrated in voltage and decibels. A plug-on 20 dB pad is supplied to extend the output range down to 0·2μV.

The output impedance is 50 ohms with a voltage standing wave ratio better than 1·2: 1. A matching pad for 75 ohm output impedance and a composite dummy aerial and d.c. isolating unit are available as accessories. Monitoring of modulation is effected by a thermocouple meter in conjunction with a calibrated potentiometer. The instrument is intended primarily for a.c. mains operation, but provision is also made for the use of external batteries. It can, if desired, be removed from its case and mounted in a standard 19in rack, the panel being ready drilled for rack mounting.

[Reply Card No. E1562]

Direct Reduction of Iron Ore

COMPLETE plants using the R-N process for the direct reduction of iron ore and the production of briquettes of a very high iron content are to be built by Head Wrightson and Co. Ltd., under an arrangement made with the R-N Corporation, of New York. The layout, design and



Pilot plant for reduction of ore by the R-N process in Alabama

supply of these plants will be undertaken by Head Wrightson Minerals Engineering Limited, Sheffield, and a considerable proportion of the equipment will be manufactured in the works of other Head Wrightson subsidiary companies on Tees-side.

It is stated that the R-N process, so called from the initials of the two companies which have combined to develop it — Republic Steel Corporation and National Lead Co.—is able to deal effectively with a wide variety of iron ores. It is essentially a simple process. Iron ore is reduced by being heated with a suitable form of solid carbon in a rotary kiln under carefully controlled conditions, and a high grade iron is subsequently extracted from the kiln product and finally delivered as briquettes of convenient size and properties for use in a variety of steelmaking processes. Our illustration shows the rotary kiln at the R-N pilot plant in Alabama, U.S.A. Since the R-N process is not dependent upon the availability of a supply of coking coal, it will be especially applicable in those countries where iron ore is found but such coking coal is not available. The iron produced can be fed directly into electric or open hearth furnaces.

Expulsion Fuse-Switch Certified for 150MVA at 11kV

A CONSIDERABLE increase in the interrupting capacity of the D-type expulsion fuse-switch made by Johnson and Phillips, Ltd., Charlton, London, S.E.7, has resulted from a research and testing programme carried out during the past year. This equipment, widely used for the protection of overhead distribution systems, to interrupt faults up to 100MVA, has now been uprated and certified for a three-phase breaking capacity of 150MVA at 11kV.

It may be recalled that the original fuse was designed in 1934, when there was no clear indication of what interrupting capacity meant, and interrupting capacity of 50MVA was assigned to it. After an initial series of tests, however, interruption of 100MVA was obtained but without the reliability associated with circuit breakers. During the recent intensive research and study of the whole phenomena of arc-control, comparatively minor changes in design enabled an interrupting capacity of 150MVA at 11kV to be obtained with complete reliability.

The new fuse-switch units are available with an interrupting capacity of 150MVA for a voltage rate of 11kV, as follows : Type D Mark I with 22kV porcelain insulators providing a high level of line insulation for ordinary purposes and Type D Mark II with 62kV porcelain insulators for use where an extra high level of line insulation is required.

Briefly, either of these units offers a combination of air-break-switch and expulsion fuse : as a fuse it is designed to provide an economic form of protection ; as a switch it can be used for normal disconnection, being operated from ground level by means of a collapsible pole. It is fully tested and certified in accordance with B.S.2692 : 1956 for operation at all current values up to 8000A at 11kV.

Each unit is designed for easy installation with single bolt fixing through a fuse mounting which consists of a galvanised malleable iron base to which the upper and lower parts of the fixed portion of the switch are fitted. The fuse link tube is a synthetic resin bonded paper tube which is open at both ends to facilitate the rapid dissipation of pressure at all current values ; it has fittings consisting of a latch-in trigger assembly and contact at the upper end and a trunnion bearing and contact at the lower. Both upper and lower parts of the switch are fitted with brush type phosphor bronze contacts which provide a positive high-pressure multi-line connection, and current carrying is entirely independent of the trunnions, bearings and trigger.

The fuse element is carried inside the link tube and holds the switch in its latched position while the element is intact. In the accompanying illustration the latch can be seen attached to the fuse element at the upper end of the tube. When the fuse blows the latch-in trigger is released and allows the switch to swing down under gravity, to the isolated position, where it provides an unmistakable indication of an interruption in the supply.

Fuse-switch for 150MVA at 11kV in the closed position

Tests in accordance with B.S.2692 were made at the C.E.S.I. Laboratories, Milan, on a three-phase circuit consisting of two expulsion fuse switches with a short-circuiting link in the third phase to ensure that the recovery voltage across each phase was not less than the line-to-line voltage. As a result of these tests the fuse switch has been fully certified, by the C.E.S.I. Laboratories, for a breaking capacity of 150MVA at 11kV.

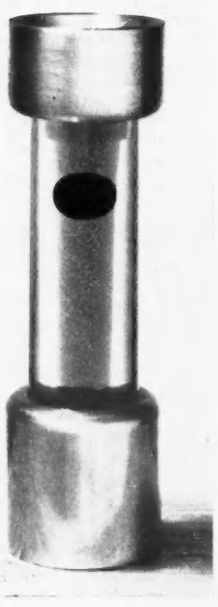
During these tests a series of frames taken on a high-speed film camera showed : first, expulsion of gas, signifying the melting of the fuse elements, one at 0·0007 second and the other at 0·002 second after application of short circuit ; secondly, dispersal of gas and circuit open at 0·014 second ; and, thirdly, the fuse carrier starting to swing down, to indicate a blown fuse, after 0·017 second.

[Reply Card No. E1571]

Lubricant Flow Indicators

MACHINES lubricated on the total loss system require some reliable indication of the flow of rather small quantities of fluid; this is often achieved by including sight glasses in the individual lubricant lines. Sight glasses, however, often fail to give clear indications with highly detergent oils, and in fact none has been fitted on Free Piston gas generators, which invariably use heavy-duty lubricants for the power cylinders. There has therefore been developed by Alan Muntz and Co., Ltd., a new design of flow indicator in which the instantaneous rate of flow is shown by the position of a ball in a transparent tapered tube. Since the new indicator contains no liquid other than the oil passing through, contamination cannot occur and fitting is easy. Each tube must, of course, be installed vertically.

The Muntz Direct Flow Indicator is available in three forms. That illustrated is the " replacement " indicator, which can be substituted immediately for existing sight glasses if they are $3\frac{1}{2}$in by $1^{1}/_{16}$in o.d., 4in by 1in o.d., or $4\frac{1}{2}$in by



Direct-flow indicator to replace existing sight glasses

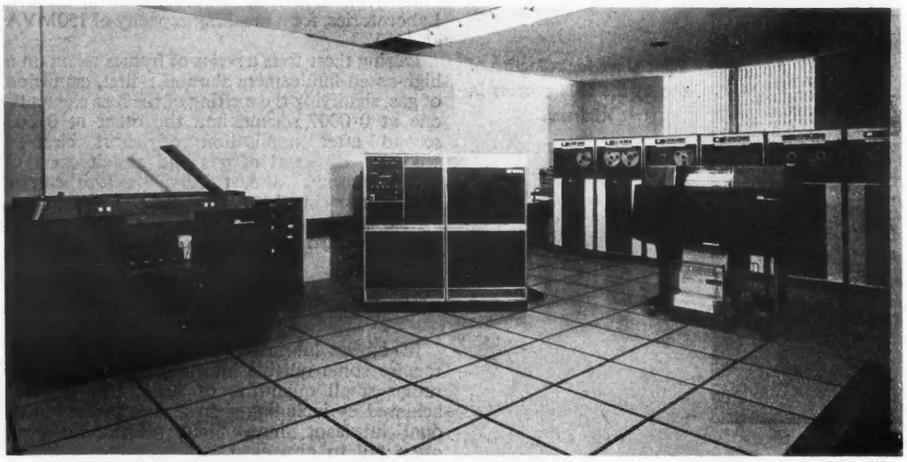
$^{5}/_{32}$in o.d.; this version responds to oil flows between 0·1 and 2·0 cubic centimetres per minute.

The standard single indicator consists of the transparent unit mounted in a brass body, $\frac{5}{8}$in A.F., with male $\frac{1}{8}$in B.S.P. ends, one long enough to clamp through a $^{3}/_{16}$in thick panel, designed to accept " Simplifix " couplings. This indicator handles flows from 0·2 to 4·0 cubic centimetres per minute.

The standard indicator is also available mounted on a panel carrying twenty-eight or, to special order, other numbers of units.

[Reply Card No. E1572]

SHORTER REPORTS *(Continued)*



Card reader and punch, computer unit and printer of business computing system, with supplementary magnetic tape storage at rear

Business Data Processing System

STYLING to suit current taste in office furnishing is evident in the various units of the IBM 1401 data processing system demonstrated on July 11 by IBM United Kingdom, Ltd., 101, Wigmore Street, London, W.1. The basic components comprise a card reader (with card punch), processing unit and line printer, together requiring a floor space of about 300 square feet. Storage in the processing unit is by means of magnetic cores in blocks of 4000 or 2000 locations, enabling up to 10,000 locations to be accommodated. Supplementary storage may be provided by up to six external magnetic tape units, as seen in the illustration. The processing unit is fully transistorised. Built-in fans provide a small flow of cooling air which enters through a grille at the bottom of the cabinet and is exhausted through a mesh screen at the top. The printed circuit boards are carried in hinged "gates" which drop forward when access to the interior is required.

Output printing takes place in a new design of printer in which the type heads (with upper case letters and numerals) form a chain as seen in the second illustration, comprising five sets of forty-eight characters. The heads move across the paper behind a printing ribbon at a speed of 90in per second and a series of hammers is operated through electronic timing circuits as each character reaches the required position. A graduated dial enables the impression to be adjusted according to the thickness of paper and density of printing desired. Movement of the paper through the printer is controlled by a puncher tape, and takes place at a speed of 33in per second or more when "skipping" lines on which no printing is necessary. Printing instructions are checked back with the store in the arithmetic unit before the impression is made. A simple code in the punched cards instructs the printer to print a delivery address in addition to the address of the invoice when these are different. Instructions may also include coding for the calculation and printing of three levels of discount. The printer accepts stationery from 3½in wide to approximately 18in wide and prints up to 132 characters in a line.

Input cards are read by the card read punch at 800 per minute, and the same unit will provide a punched card output at 250 per minute. The rate of transfer from the external magnetic tape units into the system is 62,500 characters a second.

[Reply Card No. E1581]

Chain of type faces for computer high-speed printer

Farm Machinery Finishes

A RANGE of finishes designed specifically for agricultural and horticultural machinery has been introduced by Cellon Ltd., Kingston upon Thames, Surrey. It is known as the "Cerrux 95" range and includes air-drying gloss enamels for application by spray or brush, hot spray and airless spray; an air drying red oxide primer; low bake stoving gloss enamel; a high flash etch primer, and various thinners. In recent years, much more attention has been given to the standard of finish of farm machinery, the big majority of which is worked—and sometimes still left standing!—in all kinds of weather conditions. This factor, it is claimed, has been given special consideration in the development of these "Cerrux" enamels. Other important factors such as abrasion resistance, and resistance to alkali and other chemicals, have been taken into account, as was also the need for retaining a bright appearance without colour change in a variety of climatic conditions.

In the production of these enamels, a good deal of laboratory work has been involved. We attended recently a testing and applications demonstration, the tests including those for weathering and humidity, abrasion resistance, impact and scratch resistance and chemical resistance. The company is continuing its development work on a Cerrux "Star" range which it describes as an ultra-resistant machinery finish incorporating cold cure coatings based on some new resins.

[Reply Card No. E1582]

Proposed International Conference on Road Research

DELEGATES from thirteen member and associated countries of the O.E.E.C. have recommended that an international body should be set up to foster road safety research. This was the major decision taken at a four-day international meeting, which ended last week, at the Road Research Laboratory at Langley, Bucks. It is suggested that the international body should be responsible for co-ordinating the research effort of the various countries concerned; should foster the exchange of road research information; and should recommend new researches on problems whose solution requires or would profit from international co-operation.

Sir William Glanville, who was chairman of the meeting, stressed the need for closer international co-operation in road research. He pointed out that there already existed a number of broadly based international organisations responsible for the discussion of road safety in the wide sense. The new body would work in close co-operation with them, but would be concerned with research. The meeting discussed a number of research projects which would benefit from international co-operation. Examples quoted are: (1) The priority rules for vehicles meeting at intersections; (2) Other aspects of road user behaviour, such as where pedestrians cross the road, and the care they take before doing so; (3) Road furniture (lamp standards, sign posts), kerbs, &c.; (4) The comparison of the results of accident investigation teams in various countries; (5) The examination of accident data on the effectiveness of seat belts and harnesses, and similar information on helmets for motor cyclists; (6) The study of the effects of speed limits on accidents, particularly in towns; and (7) The study of the effect of alcohol and drugs.

Launches and Trial Trips

AMORIA, oil tanker; built by Smith's Dock Company, Ltd., for Shell Tankers, Ltd.; length between perpendiculars 530ft, breadth moulded 69ft 3in, depth 39ft, draught 29ft 10in, deadweight 18,062 tons, service speed 14½ knots; thirty-three cargo oil tanks, one cargo pump room; four 400 tons per hour turbine-driven centrifugal cargo pumps, two 200 tons per hour vertical duplex stripping pumps; two 400kW diesel-driven alternators and one 100kW steam-driven alternator; Hawthorn-Doxford, single-acting, two-stroke, supercharged oil engine, six cylinders of 650mm bore, 7500 b.h.p. at 112 r.p.m., 14.5 knots. Trial, May.

BRITISH GULL, oil tanker; built at Govan by Harland and Wolff, Ltd., for the B.P. Tanker Company, Ltd.; length between perpendiculars 495ft, breadth moulded 69ft, depth moulded 37ft, deadweight 15,300 tons (summer draught), 13,700 tons (service draught), twenty-seven cargo oil compartments, two cargo pump rooms; two 250kW diesel-driven generators and one 75kW steam-driven generator; Harland and Wolff single-acting, two-stroke opposed-piston oil engine, bore 750mm by 2000mm combined stroke, 112 r.p.m. Trial, April 29.

WESTBURN, cargo liner; built by the Burntisland Shipbuilding Company, Ltd., for the Alexander Shipping Company, Ltd.; length between perpendiculars 430ft, breadth moulded 61ft 9in, depth moulded to upper deck 38ft 3in, load draught 28ft 10in, deadweight 11,900 tons; five holds, one 50-ton, six 12½-ton and eight 5-ton derricks; three 200kW diesel-driven generators; Hawthorn-Doxford, two-cycle, opposed-piston oil engine, 5500 b.h.p. at 115 r.p.m. Launch, May 11.

INDUSTRIAL NEWS

Iron and Steel

Iron and steel production in June was affected by the Whitsun holiday. Pig iron output averaged 295,200 tons a week, compared with 299,100 tons in May, and steel output was running at 466,400 tons a week, compared with 475,400 tons a week in May and 388,500 tons a week in June last year. The Iron and Steel Board says that calculations have been made to correct steel production rates for interruptions caused by the Easter and Whitsun holidays and other seasonal influences. These corrected figures, the Board explains, show that steel output maintained a moderate rate of advance during the first half of this year after the substantial rise during 1959. The June figure indicates that steel production recovered from the temporary set-back in May which resulted partly from the bunching of repairs at steel making furnaces and partly from an interruption in the flow of pig iron during the relining of blast furnaces at integrated plants. It can be added that steel production in the first half of this year amounted to 12,390,000 tons and was in line with the total expected for the year as a whole, which has been put at 24,300,000 tons.

The estimated demand for steel for the whole of this year is 26,000,000 tons, a figure which includes an addition to stocks of 1,200,000 tons. The Board says that credit restrictions introduced by the Government have not so far made any noticeable impact on the home usage of steel or on the tendency which has been evident since last Autumn for users to rebuild their stocks. Moreover, the substantial order books which exist for most steel products suggest that there is not likely to be any early effect on steel production. This year's estimates include a provision for exports of 4,400,000 ingot tons. Exports in the first five months of this year were at this rate and, according to the Board, " give grounds for expecting that the estimated total for the year will be reached." The high rate of exports this year has resulted mainly from increasing trade in plates, heavy sections and tinplate. Exports of plates and heavy sections have been at a rate more than twice the 1957 figure and tinplate has shown a gain approaching 40 per cent.

Coal Mining Hours

Last week, the National Reference Tribunal for the Coal Mining Industry issued its award on the claim by the National Union of Mineworkers for a seven-hour day (plus one winding time) for underground workers and for a forty-hour week (including meal times) for surface workers. The Tribunal has awarded that underground hours should be reduced by one hour a week and leaves it to the National Coal Board and the union to agree on the best arrangement to give effect to that reduction. The Tribunal has rejected the union's claim to make the hours of surface workers inclusive of meal times, but has awarded that the maximum hours of those workers should also be reduced by one hour a week. The Tribunal has stipulated that the award should come into operation on such date between five and seven months from July 8, 1960 as the National Coal Board and the National Union of Mineworkers may agree.

The present working hours in the coal mining industry are 7½ hours a day underground (plus one winding time) and 42½ hours a week (excluding meal times) on the surface. One winding time is the time taken to ride a complete shift of men up or down the colliery shaft and its average length, for the whole country, is twenty-seven minutes.

Wages and Hours of Work

Up-to-date particulars about minimum or standard rates of wages and of the length of the normal working week in more than 200 industries and services in the United Kingdom are given in the fourteenth edition of *Time Rates of Wages and Hours of Work*, compiled by the Ministry of Labour, which has just been published (H.M. Stationery Office, price 16s.) This new edition, which revises the 1959 volume, has nearly 300 tables ; they give summaries of the main provisions of voluntary collective agreements between organisations of employers and workpeople, or made by Joint Industrial Councils or other similar bodies, and of a number of Statutory Orders under the Wages Councils Acts. In addition to current time rates of wages and hours of work the tables give particulars, where available, of the basic rates for piece workers, additional rates for shift and night workers, and of arrangements, if any, for a guaranteed weekly wage or period of employment. Such advance information as was available at the time of going to press about reductions in the normal working week to operate from future dates is also included. Three appendices contain details of rates of wages for young workers in a selection of industries, and of overtime rates of pay, and of arrangements for paid holidays in the industries and services included in the main tables.

Pneumoconiosis Survey

Information on pneumoconiosis as it occurs in ironfoundries is limited, and it has hitherto been difficult to compare and correlate the knowledge gained from different sources. Moreover, the greater part of the known information refers to the experience of a relatively small number of the larger ironfoundries. In an attempt to gain an appreciation of the extent and nature of the risk in the smaller ironfoundry, the Council of Ironfoundry Associations has carried out a survey in forty-four foundries in Scotland, the Midlands and N.E. and N.W. England, examining altogether 1437 volunteers (about 88 per cent of their labour force). The results obtained have been more reassuring than many had feared. However, the Council says, they give no ground for complacency, but will serve to encourage the industry in its efforts to control the dust causing the disease. No clinical examinations were made because it was feared that these might have deterred men from co-operating in the survey, and because of the loss of working time that would have been involved. This must qualify the accuracy of the findings in the case of the individual man, since a clinical examination is needed for any firm diagnosis of pneumoconiosis. However, a chest radiograph and details of occupation and health histories were taken in respect of each man. These details, when taken together, have allowed general conclusions to be drawn, bearing in mind that an abnormal pattern on the radiograph of a worker exposed for years to the inhalation of dust during work is likely to be produced by retention of dust in the lungs, probably associated with the formation of fibrosis or scar tissue.

As a result of the examinations, 1338 men were informed that their radiograph showed no significant abnormality ; sixty-eight men were advised to consult their doctors on the grounds that their radiographs and other information supplied by them, appeared to indicate an occupational chest condition warranting further examination. Of the 1437 radiographs taken, forty-one (2·9 per cent) showed lung changes suggesting marked dust retention, 282 (19·6 per cent) showed changes suggesting moderate dust retention and 747 (52 per cent) showed changes suggesting slight dust retention. Evidence was found, however, that the factor of age was of no less importance than length of exposure to occupational dust when assessing the causative factors of X-ray change.

Youth Employment and Further Education

The second volume of the Crowther report (" 15 to 18 ") has just been published by the Central Advisory Council on Education (H.M. Stationery Office, price 8s. 6d.). It sets out the findings of three surveys, made between 1956 and 1958, dealing with adolescents and young workers. Particulars were obtained about 30,000 young people, the majority of them men, all of whom had left school.

One part of the report deals with what is described as a social survey. This survey indicates the importance of home background in the pursuit of a career. It shows, for example, that 45 per cent of boys and 40 per cent of girls who had attended selective schools and who came from the homes of professional and managerial people proceeded either to full-time education or professional employment. For the boys and girls from the same kinds of school whose parents were in non-skilled employment, the figures were only 17 per cent for boys and 21 per cent for girls. The report adds that " the proportion of boys and girls going into full-time education or professional work from the modern school was almost negligible."

Another section of the report sets out the findings of a " technical courses survey " which was made between 1956 and 1958. From this survey it has been deduced that about one in four of young men initially enrolled for a National Certificate course attains his Ordinary National Certificate, and that about one in ten reaches the level of the Higher National Certificate. The report says that, among other matters, this survey has revealed the handicaps to which the boy without day release is subjected ; the likelihood of his achieving a Higher National Certificate is shown as about half that of other students. Furthermore, the survey gives strong grounds for supposing that the boy starting on his course with a good G.C.E. qualification is appreciably the more likely to succeed.

PERSONAL AND BUSINESS

Appointments

GENERAL SIR GEORGE ERSKINE has been appointed a director of Securicor, Ltd.

DR. T. F. WEST has been appointed editor of *Chemistry and Industry*, the weekly news organ of the Society of Chemical Industry.

MR. W. A. CUSINS has been appointed export sales manager and Mr. B. Noble home sales manager of Belliss and Morcom, Ltd.

MR. KEITH HIGGINS has been appointed publicity officer and Mr. Peter Jarvis public relations assistant of Coventry Climax Engines, Ltd.

DR. GORDON D. ROSEN has been appointed general manager of International Protein Products, Ltd., a subsidiary of British Glues and Chemicals, Ltd.

MR. F. H. SCHROEDER, M.I.Mech.E., A.M.I.E.E., has been appointed to the board of directors of Metal Industries, Ltd.

MR. G. R. SHOTTON, managing director of Shotton Brothers, Ltd., has been elected president of the Institute of British Foundrymen for the year 1960-61.

MARCONI'S WIRELESS TELEGRAPH COMPANY, Ltd., has announced that Mr. G. D. Speake has been appointed deputy chief of research at Marconi's research and development laboratories, Great Baddow, near Chelmsford, Essex.

TUBE INVESTMENTS, Ltd., states that Mr. W. W. Hackett has accepted an invitation to become the first President of Accles and Pollack, Ltd. He has just retired from the chairmanship of the latter company, with which he has served for sixty-one years.

HEAD WRIGHTSON AND CO., Ltd., announces the appointment of the following general managers among its subsidiary companies: Mr. W. H. Adams, Head Wrightson Iron and Steel Works Engineering, Ltd.; Mr. J. D. Eccles, Head Wrightson Steel Foundries, Ltd.; Mr. G. W. Wilson, the Cupola Mining and Milling Company, Ltd.

THE MARCONI INTERNATIONAL MARINE COMMUNICATION COMPANY, Ltd., has announced the following appointments: Mr. R. C. Older, buildings and transport manager; Mr. L. A. Hooper, personnel and training manager; Mr. F. E. Ash, marine staff recruitment and welfare superintendent; Mr. G. Nash, technical information branch manager.

MR. E. COVERDALE, chairman and joint managing director, and Mr. P. Coverdale, joint managing director, of Permoglaze Holdings, Ltd., have joined the board of Blundell, Spence and Co., Ltd. Mr. E. B. Calvert, chairman and managing director of the latter company, and Mr. A. F. Bacon, executive director, have been appointed directors of Permoglaze Holdings, Ltd., and Permoglaze, Ltd.

BRITISH TRANSPORT COMMISSION announces that Mr. G. R. Hayes has become assistant secretary of British Road Services. Mr. P. S. Rae-Scott has been appointed commercial manager B.R.S. (Contracts), Ltd., following the appointment of Mr. A. J. Pragnell to the post of divisional traffic officer B.R.S. (Pickfords), Ltd. Mr. E. Froggatt has been appointed assistant divisional manager, South Eastern Division, B.R.S., and has been succeeded as district manager, West Yorkshire District by Mr. H. Cliff. Mr. W. Partington has been appointed to the new Pickfords post of assistant heavy haulage manager (northern) and has been succeeded as north-eastern area manager by Mr. E. G. Milne. Mr. S. B. Bowskill has been appointed Midland area manager of Pickfords heavy haulage organisation.

Business Announcements

MR. C. W. ALLIN has resigned from the boards of Redler Industries, Ltd., and its subsidiaries.

PANTHER CEILINGS Ltd., has been acquired by Ayrshire Dockyard Company, Ltd., a member of the Lithgow group of companies.

SPIRAX-SARCO, Ltd., Cheltenham, has moved its London office to 41, Curzon Street, W.1 (telephone, Grosvenor 1671-2).

THE L. S. STARRETT COMPANY, Ltd., has been established at Jedburgh, Scotland, as a subsidiary of the American Starrett Company, manufacturing tools and measuring instruments.

DOWTY HYDRAULIC UNITS, Ltd., has completed licence arrangements with Berry Hydraulics, Mississippi, and Malcolm Moore Industries, Ltd., Melbourne.

C. C. WAKEFIELD, Ltd., states that, from August 2, its title is to be Castrol, Ltd. The company also announces that the recently-acquired subsidiary De-Corrosion Services (Norwest), Ltd., is to be known as Metal Cleaning, Ltd.

DAVID BROWN-FOOTE GEARS, Ltd., has been formed in Toronto to take over the sales and distribution in Canada of gear transmissions and chain products manufactured by the David Brown Corporation, Huddersfield, and Foote Brothers Gear and Machine Corporation, Chicago. In addition, the latter company has taken over the gear division of David Brown Inc., San Leandro, California, and will be responsible for the sales and distribution of David Brown gear products in Western U.S.A.

BRISTOL AIRCRAFT, Ltd., Filton House, Bristol, announces that its aircraft sales and service departments have been amalgamated. The following organisational changes have also been announced: Mr. Walter F. Gibb, chief test pilot, has been appointed sales and service manager, aircraft; Mr. Roger White-Smith, sales manager, has become deputy sales and service manager, aircraft; Mr. Godfrey Auty, deputy chief test pilot, has succeeded Mr. Gibb as chief test pilot. Mr. J. C. Harrington, service manager, aircraft, is relinquishing his appointment with the company at the end of the current month.

E.M.I. ELECTRONICS, Ltd., Hayes, Middlesex, and the Swedish SAAB AIRCRAFT COMPANY have signed an agreement for technical and commercial co-operation. SAAB is to sell E.M.I.'s equipment in the industrial, automation, broadcasting, instrument and special tube fields throughout Sweden, Norway and Denmark through its sales organisation SAAB Electronics, Stockholm. E.M.I. Electronics is to market SAAB products in the British Commonwealth and other countries. The two companies have agreed to exchange technical information and licences in the future.

S. SMITH AND SONS (ENGLAND), Ltd., has announced the formation of a new division to integrate its business in industrial products, which have hitherto been made or marketed by the following subsidiaries: Smiths Industrial Instruments, Ltd.; Kelvin and Hughes (Industrial), Ltd.; and David Harcourt, Ltd. The assets and undertakings of these three companies will be transferred to S. Smith and Sons (England), Ltd., with effect from midnight July 31. The undertaking so transferred, together with the appropriate manufacturing activities of S. Smith and Sons (England), Ltd., will then comprise, and be formally established as the industrial division of S. Smith and Sons (England), Ltd., with the trading style, Smiths Industrial Division. Mr. W. M. Cann will be general manager of the new division. The head office of the new division will be at Chronos Works, North Circular Road, London, N.W.2.

Contracts

HALL, RUSSELL AND CO., Ltd., announces the receipt of a contract from the Burnett Steamship Company, Ltd., for the construction of a single deck bulk cargo vessel of about 7500 tons deadweight. The dimensions of the vessel are as follows: length between perpendiculars, 383ft; breadth moulded, 55ft 6in; depth moulded, 31ft. Propelling machinery will consist of a Sulzer diesel engine of 3840 b.h.p.

THE GENERAL ELECTRIC COMPANY, Ltd., has received an order from the British Transport Commission for sixty-nine sets of electric traction, control and auxiliary equipment for 1250 h.p., Type 2, diesel-electric locomotives to be built by the Birmingham Railway Carriage and Wagon Company, Ltd. The diesel engines will be the Sulzer "6LDA28-B," an up-rated version of the 1160 h.p. "6LDA28" fitted in previous Type 2 locomotives in which increased output is obtained by a simple intercooling system using the engine cooling water circuit for charge-air cooling.

A. MONK AND CO., Ltd., has been awarded a contract for rebuilding 2 miles of the Great North Road (A.1), between Ellington Brook bridge and Alconbury in Huntingdonshire. Work will start immediately and should be completed by the spring of next year. The contract is valued at £194,759; two carriageways, each 24ft wide, will replace the existing single carriageway, which has a number of sharp bends and is subject to flooding from the Alconbury Brook. The new road will be above flood level, and the old road will be left to serve, in places, as a lay-by, and for access to farm land. The contract forms part of the programme for the comprehensive improvement of the Great North Road, and will be carried out under the supervision of the county surveyor of Huntingdonshire, Mr. R. E. C. Dorling.

THE EAST ANGLIAN REGIONAL HOSPITAL BOARD has awarded a contract worth approximately £250,000 to the Mitchell Construction Company, Ltd., of Peterborough, for work in connection with the development of the Peterborough and District Memorial Hospital. The contract covers the construction of a boiler-house and mortuary block and forms Stage 2 of the first phase of the complete scheme. The architect to the Board is Guy Aldis, A.R.I.B.A., A.A.Dipl., of Cambridge.

THE CLEVELAND BRIDGE AND ENGINEERING COMPANY has a Ministry of Transport contract valued at £329,216 for the first stage of the scheme to by-pass Port Talbot on the London-Fishguard Trunk Road, in Glamorgan. The contract covers the widening of the existing road between Raglan and Briton Ferry, a distance of just over 1 mile, which will be converted into a dual 24ft carriageway with 9ft cycle tracks and 6ft footways. The scheme was designed by Sir Owen Williams and Partners, consulting engineers, and the work is expected to take about fourteen months.

THE ENGLISH ELECTRIC COMPANY, Ltd., has received an order worth about £500,000 for rectifiers and transformers for Hindustan Aluminium Corporation. The equipment, to be shipped to a new plant in the spring of 1961, will supply direct current power for aluminium smelting. The plant is in Uttar Pradesh State near the Rihand power station, which is intended as the main source of electricity for the smelting, and contains five English Electric 77,000 h.p. water turbines. The rectifiers and transformers in this new order will be made at the company's Stafford works. The main transformers consist of two 60MVA, 132kV1, 11kV units and two 56MVA, 11kV regulating units. The six rectifier equipments each consist of a transformer and a group of air-cooled sealed steel tank mercury arc rectifiers. Each group of rectifiers is rated at 10,000A, 750V direct current. The total load capacity is 45MW. The contract also includes control gear, d.c. switchgear and auxiliaries. Consultants for the plant are Kaiser Engineers of Oakland, California.

THE GENERAL ELECTRIC COMPANY, Ltd., has received an order from the Electricity Department of the Qatar Government for two 15MW single pass-out turbo-generators for installation in the Ras Abu Aboud power station. The order, which is valued at nearly £700,000, includes the condensing plant and boiler feed pumps, together with the cranes, compressed air system, and the air conditioning and ventilation plants for the station. The power station is to be on the coast, about 3 miles east of Doha and 24 miles north of Umm Said, and is to be linked with the electrical networks of these towns by underground cables and overhead lines, respectively. The new turbo-generators will be suitable for operating in parallel with five 2600kW, 11kV diesel generating sets already installed at Doha. The turbo-generators are rated at 11kV, 15MW, 50 c/s, with turbine stop valve steam conditions of 600 lb per square inch gauge and 850 deg. Fah. Pass-out steam is to be used for distillation of sea-water to produce drinking water, some 110,000 lb per hour of steam at 12 lb per square inch gauge being bled off. The turbines exhaust at 27½in vacuum. Delivery of the first set is scheduled for December, 1961, and that of the second set for March, 1962. Consulting engineers for the project are Messrs. Preece Cardew and Rider.

Miscellanea

OIL TERMINAL AT TRANMERE.—With reference to an article having this title which appeared in our issue of July 8, we wish to state that the two bunker pumps were manufactured by Plenty and Son, Ltd., and that these were the only constant-pressure pumps with reversible flow in the installation.

ADVANCED GAS-COOLED REACTOR AT WINDSCALE.—In describing the A.G.R. at Windscale we stated (page 968) that "Four circulators and heat exchangers (International Combustion, Ltd.) are installed, principally for safety reasons." We have been asked to point out that the circulators are being supplied by James Howden and Co., Ltd., as direct maincontractor to the U.K.A.E.A. and that the motors driving the circulators are being made by Laurence Scott and Electromotors, Ltd., as sub-contractor for this contract. The reference to "safety" in the sentence quoted above should be taken to mean that four was not necessarily the optimum number of heat exchangers but that this number was chosen mainly for safety reasons.

CONTINENTAL AFFAIRS

by Our Continental Editor

High-Voltage Insulators with Helicoidal Sheds

A new design of high-voltage insulator having helicoidal sheds was described in a paper presented at the recent meeting of C.I.G.R.E. in Paris. Unit insulators have been developed for 15kV, 30kV and 45kV and strings can be made up for higher service voltages. Designs are available for high-voltage lines and for outdoor electrical equipment, as described below. Some test results are given.*

THE new design of high-voltage insulator illustrated here differs from conventional insulators in that it is asymmetrical. It is all-ceramic and consists of a solid core surrounded by sheds in the form of a spiral ramp. The main object of this spiral ramp is to ensure an even potential gradient along the spiral surface and to arrange that surface is well washed by rain without allowing water to drip between the sheds.

A great deal of research and development work has been carried out by the manufacturer of this insulator—the Compagnie Générale d'Electro-Céramique, France—first on the shape and dimensions of the shed which have a critical effect on the characteristics, secondly, on the fitting of the hardware ends and, thirdly, on the manufacture of the porcelain.

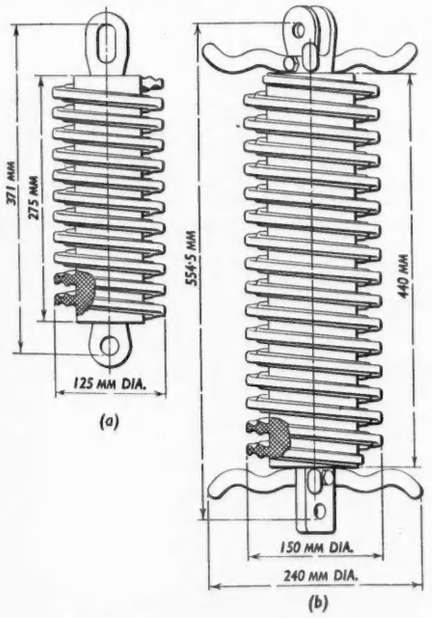


Fig. 1—Spiral shed insulators (a) for 30kV line; (b) for 45kV line

The first design produced with spiral sheds was intended to meet the specification C11.200 of the Union Technique de l'Electricité for 15kV distribution lines, which specifies a flashover voltage (in rain) at industrial frequency, of 55kV, and a withstand impulse voltage with a 1/50 wave of 150kV crest value. In the original design the corresponding values achieved were 44kV and 139kV. One reason for this unsatisfactory performance was that with the spiral pitch chosen rain-water was able to trickle from one shed to the next and the flashover voltage was reduced accordingly. It was evident that the pitch must be modified to bring adjacent sheds closer together and that the section of the ramp must be changed to form a water channel along the helix which would improve the washing effect.

Attachment of the hardware is effected by cementing in the two fittings, into blind holes, one at each end of the insulator body. This departure from the familiar cap enables the flashover distance and the leakage path to be increased considerably. For a given mechanical strength the former construction requires a greater core diameter, but the spiral sheds can be closely pitched, giving a long leakage path. The maker states that, for given mechanical and electrical characteristics there is no appreciable increase in the total diameter over the sheds, compared with that of the normal shed design.

The pins that are cemented into the blind holes at the ends of the insulator core have tapered shanks provided with thin elastic flanges with adequate shear resistance to transmit the load between the pin and the insulator core. The shank of the flanged pin is conical to increase the elasticity of the flanges near the base of the hole.

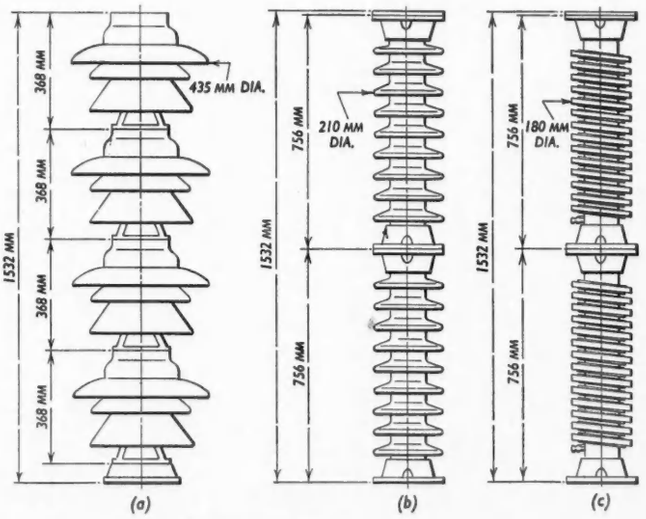
A comparison between the final design of the 15kV insulator with spiral sheds and the equivalent string of two CT155 cap-and-pin insulators, is given in Table I. Radio interference tests and mechanical tests have also been carried out.

Spiral-Shed Insulators for Overhead Lines.—The 15kV design referred to above has been scaled-up to give designs suitable for 30kV and 45kV for overhead lines and these insulators are shown in Fig. 1 (*a*) and (*b*). In this scaling-up process it has proved advantageous to maintain an angle of about 90 deg. (in plan) between the upper and lower ends of the spiral shed.

For voltages higher than 45kV units such as that shown in Fig. 1 (*b*) can be strung in series: for example, three units for 150kV, four units for 220kV service voltage. Articulation of the members making up the string is provided by orienting the axes of the hardware connecting pins at 90 deg. as suggested by Fig. 1 (*b*). It is considered that the length of the porcelain in an insulator of this kind should not exceed 500mm. With ordinary porcelain the insulator illustrated here is stated to be able to carry an axial load of 7 tons with an ample factor of safety.

TABLE I—*Comparison Between Spiral Shed Insulator and Cap-and-Pin String for 15kV*

	Spiral shed insulator		2×CT155 insulator string
Comparative dimensions, mm :			
Overall length	238	...	307
Diameter of sheds	125	...	155
Tests at 50 c/s :			
Dry flashover voltage, kV R.M.S.	108	...	110
Dry withstand voltage, kV R.M.S.	100	...	102
Wet flashover voltage, kV R.M.S.	66	...	54
Wet withstand voltage, kV R.M.S.	61	...	50
Impulse tests, 1/50 wave.			
50 per cent flashover :			
Positive wave, kV crest	201	...	126
Negative wave, kV crest... ...	216	...	135
Withstand voltage :			
Positive wave, kV crest	189	...	118
Negative wave, kV crest... ...	201	...	125
Pollution test :			
Number of cycles to flashover...	17	...	7



(*a*) Pillar insulator.
(*b*) Cylindrical insulator with ordinary sheds.
(*c*) Cylindrical insulator with spiral sheds.

Fig. 2—Three outdoor insulating columns for 170kV reduced insulation

In Table II we reproduce the results of comparative tests on a string of thirteen cap-and-pin insulators (type CT254) with a pitch of 130mm and a string of three spiral shed insulators having a pitch of 589mm. In these tests the

TABLE II—*Comparison of Three Spiral Shed Insulators with Thirteen Cap-and-Pin Insulators*

	Thirteen units type CT 254		Three units with helicoidal sheds
Length of the string (including the top suspension ring and the clamp fixing pieces), mm	1,843	...	1,862
Arcing length, mm	1,736	...	1,488
Withstand voltage at 50 c/s in rain, kV R.M.S.	440	...	448
Withstand voltage at 50 c/s in rain in kV R.M.S. corrected for a length of 1,902 mm	455	...	459
Impulse withstand voltage :			
Positive wave, kV crest	910	...	948
Negative wave, kV crest	950	...	990
Impulse withstand voltage corrected for a length of 1 902 mm :			
Positive wave, kV crest	941	...	972
Negative wave, kV crest... ...	982	...	1,014

* "New Insulators with Helicoidal Sheds for Lines and High-Voltage Apparatus," by L. Gion and H. Meier, Conférence Internationale des Grands Réseaux Electriques à Haute Tension, 112, Boulevard Haussmann, Paris.

CONTINENTAL AFFAIRS *(Continued)*

spiral shed insulators were equipped with cruciform arcing horns, but the cap-and-pin insulator string had no such protective accessories.

From this table it can be deduced that the characteristics of the spiral shed insulators in rain are equal to those of the cap-and-pin string and that the positive wave impulse withstand voltage is 3 per cent higher.

Spiral Shed Insulators for Electrical Equipment.—Similar insulators have been developed for electrical equipment for 7·5kV to 420kV. A dimensional comparison with two conventional forms of insulator is made in Fig. 2 and the results of tests on these insulators is given in Table III.

TABLE III—*Comparison of Outdoor Insulators Shown in Fig.* 2.

	Withstand voltage 1mm at 50 c/s in rain (kV R.M.S.)	Impulse withstand voltage 1/50 wave	
		Positive (kV crest)	Negative (kV crest)
Four units pillar type...	353	695	789
Two cylindrical units classical shed type ...	390	695	930
Two cylindrical units with spiral sheds ...	405	705	726

Oxygen Pipe Network

A few weeks ago the official opening took place of a new oxygen plant at Richemont, between Hagondange and Thionville, in the centre of the Lorraine iron and steel production area. The plant belongs to Oxylor, a subsidiary of the Air Liquide company and is designed to supply the eleven most important steel plants of Eastern France with oxygen through a system of pipelines.

The oxygen plant at present comprises one unit producing 2400 litres per hour of liquid oxygen, and a second unit capable of an output of 150 tonnes per day of gaseous oxygen. A third stage, at present under construction, will produce 200 tonnes per day of gaseous oxygen. The 90m-long building can at a later date be expanded to a length of 300m in order to instal further production capacity ; the structure is of reinforced concrete, with a metallic roof.

From the oxygen factory leads a 400m-long double trunk of 350mm diameter pipes which branch out in two main directions, to the north and south, of which the southern branch is the longer one. Its first 4km, consisting of 300mm diameter pipe, extend from Richemont as far as the feeder to the U.C.M.P.I. plant (Union des Consommateurs de Produits Métallurgiques et Industrielles) and the S.A.F.E. plant at Hagondange.

From the branching point, the pipe continues with a diameter of 250mm to the Sidelor plant at Rombas, which is reached by a short feeder. Another feeder at that point branches off to the de Wendel steel works at Moyeuvre. There then follows 1·3km of line with a diameter of 175mm, and another feeder to the Sidelor works at Homécourt. The pipeline ends with a 2500m long section of 100mm diameter to the Sidelor centre at Auboué.

The northern branch begins with a stretch of 300mm and 250mm diameter pipe to the " Nord et Lorraine " works at Uckange, then continues with a diameter of 200mm as far as the junction to the Lorraine-Escaut and Sollac steel works. From there onwards, a 4000m trunk of 175mm diameter serves the de Wendel plant at Hayange, and continues for another 4km to Knutange, to the S.M.K. steel plant (Société Métallurgique de Knutange).

Because of the heavily industrialised nature of the district and the nature of the gas to be pumped, certain difficulties had to be overcome with respect to siting, and the material for the pipes. Thus, the pipelines had to be taken under the busy main line at several points and the River Orne, a tributary of the Moselle, had to be traversed in three places. The quality of the gas has led to special measures being taken to exclude dangerous rusting and oxydation. The pipes are covered externally with special material, and internally are coated with anti-rust composition. Pressure tests were carried out at 40 atmospheres, by means of compressed nitrogen in place of water.

First German Drive-in Cinema

Opened recently near a favourite excursion point on the southern fringes of Frankfurt-on-Main, the first German drive-in cinema—and after Rome and Madrid, the third on the Continent—can accommodate over 1100 private cars in an auditorium of 82,000 square metres. The screen measures 36m in width and 15m in height, and its lower edge is 7m above ground level. In the projector building are housed two Bauer " U-2 " projectors suitable for 35mm as well as 70mm film and for standard films as well as Todd-AO, Cinemascope, &c. There is also a projector for slides. Each of these projectors consumes up to 170A. Light from the carbon arcs is filtered of heat rays by special mirrors in order to avoid undue heating of the films and slides. Sound is provided by a Siemens installation including three amplifiers of 100W output each, which are connected by cables to 1100 loudspeakers. These speakers are hung from posts distributed over the parking area and have leads sufficiently long to allow them to be brought inside the cars, so that windows can remain closed in cold weather. By using two or more synchronised sound tracks in different languages, performances can be given in more than one language simultaneously. Mains voltage socket outlets are provided which allow portable heaters to be plugged in so as to keep the car interior warm with engines turned off. Over 30 km of distribution cables were emplaced for the loudspeakers and mains supply as well as for the light-signal paging system. Power is provided by a special substation for 450kVA, 4kV/380V/220V.

Drive-in cinemas, while new to Europe, are well-known in the United States where over 5000 are in existence ; thirty-eight have been installed in South Africa.

Jet Flame Drilling and Working of Stone

Uses of high velocity jet flames for mining and quarrying operations were demonstrated to Scandinavian quarry operators recently. The demonstration was given by Union Carbide Europa S.A. of Geneva, with the co-operation of Svenska A.B. Gasaccumulator, Stockholm-Lidingo, at one of the quarries of Granit A.B. Kullgrens Enka on the island of Bohus-Malmoen. The equipment easily cuts channels in granite quarries, drills blast holes, and gives an extremely attractive texture to granite surfaces. The basic process, known as " jet-piercing," was developed about twenty years ago for drilling blast holes in taconite, a species of iron ore which had, for years, been most difficult to drill with conventional mechanical drilling tools. The high temperature required to spall the granite and other stone is generated by burning oxygen and kerosene under pressure. It is the spalling action, not melting, that produces the channel or the hole in the stone.

Water is used as a coolant for the combustion chamber and burner nozzle, and in addition quenches and embrittles any material in the rock which may have become fused by the jet flame. A large portion of the water turns to steam which together with the burned gases carries the particles of disintegrated rock out of the hole.

In operation, the jet channelling blowpipe directs a single reaction flame into the stone in the direction of the required channel. When the channelling operation is under way, the blowpipe is moved vertically over the full depth of the channel, removing a 1in to 2in thick layer of stone. The wash of the flame is used to keep the completed channel clean and unobstructed. Equally important is the fact that the surface of the block cut out by jet channelling is quite smooth. Blocks cut by conventional drilling methods require extensive finishing to remove the deep parallel grooves left by the drills.

Unlike churn drills, pneumatic drills, and jack hammers which pulverise rock, the jet-flame eats its way through rock and ore quickly, attaining on average drilling speeds of 15ft to 20ft per hour. Depths of over 140ft have been reached with jet-piercing equipment and channelling rates average 22 square feet per hour ; speeds in excess of 50 square feet per hour have been attained in granite. Mechanical methods, it is claimed, usually will not exceed 7 square feet per hour. Because of its speed and versatility, one jet-piercing unit, it is stated, will do the work of several drillings rigs. Materials which have been successfully worked include quartz, quartzite, sandstone, granite, taconite, dolomite, rhyolite, and syenite.

To illustrate further the versatility of its processes in quarry operations, Union Carbide also demonstrated thermal texturing which is brought about by the action of flame heat from a special torch passing quickly over the surface, which causes the stone to spall off in controlled small amounts. The textured granite looks fresh with the glint of quartz, feldspar and biotite which it contains. The attractive appearance is stated to be due to the spalling action taking place along natural cleavage planes or crystal boundaries, which is not the case when abrasive or steel tools are used.

Inauguration of Mol Nuclear Fuel Processing Plant

On July 7, His Majesty King Baudouin inaugurated the construction at Mol, in Belgium, of the world's first internationally-owned nuclear fuel processing plant. The plant is being built by Eurochemic, the European company for the Chemical Processing of Irradiated Fuels, which is one of the joint projects of the O.E.E.C. European Nuclear Energy Agency. It is scheduled to begin operation in 1963, and will be used by the thirteen participating countries (Austria, Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey) for processing used fuel elements from their nuclear reactors, in order to separate fission products and plutonium, and to recover unused uranium.

Utkal Machinery Private, Ltd.

It is announced that the German firms Gutehoffnungshutte Sterkrade Aktiengesellschaft, Oberhausen, Heinrich Koppers G.m.b.H., Essen and J. M. Voith, Heidenheim (Brenz), in conjunction with the Indian firm Larsen and Toubro, Ltd., Bombay, have founded a mechanical, engineering and structural steelwork undertaking in India. The name of the new firm is Utkal Machinery Private, Ltd., with seat in Bombay. The works are to be sited in Orissa, near the Rourkela steel plant. The new company, which has a capital of 50,000,000 rupees held in equal parts by each of the founder companies, is stated to have obtained an Indian Government licence to produce important products from the range of manufactures of the German companies, thereby helping to ease India's foreign exchange shortage.

Iron Ore Sintering Machine

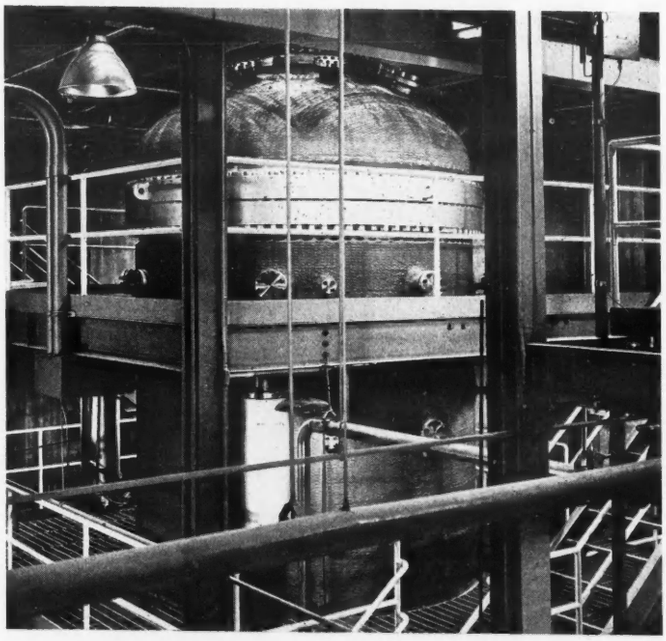
A contract for what is stated to be the largest iron ore sintering machine in Europe has been awarded to Lurgi Gesellschaft fuer Chemie und Huettenwesen m.b.H., Frankfurt, by H.A.D.I.R., Differdange, Luxembourg. The 3½m wide machine has a capacity well above 4000 tons of sinter per day using mainly Minette ores. Its design is similar to the two 4m machines recently supplied to Broken Hill Proprietary Company, Ltd., Newcastle, and Australian Iron and Steel Company, Port Kembla, Australia.

THE AMERICAN SCENE

by Our American Editor

Special Power Excursion Reactor Test in Idaho

The Special Power Excursion Reactor Test No. 2 (SPERT-II), a versatile experiment for studying nuclear reactor safety, recently reached criticality at the U.S. Atomic Energy Commission National Reactor Testing Station near Idaho Falls, Idaho. The total cost of the installation, including equipment and heavy water, is approximately 4,000,000 dollars. In the initial operation of SPERT-II, either light or heavy water can be used as the coolant, moderator and reflector. Provision has also been made for varying the reflector thickness and for accommodating solid reflectors, such as beryllium.



THE Special Power Excursion Reactor Test No. 2, or SPERT-II is one of a series of reactors developed for the Commission by the Phillips Petroleum Company as part of a programme to find basic explanations for reactor behaviour under runaway conditions. Its primary purpose is to provide the means of determining how various moderator and reflector materials influence reactor behaviour. The reactor operations are conducted remotely since some tests approach conditions which could lead to reactor destruction. The extreme conditions simulated in the SPERT tests would not normally occur in operating power reactors. Data derived from the experiments will have specific application to many military and civilian power reactors currently in use or under construction. The aim of the programme is to gain such a knowledge of the behaviour of reactors that plants can be designed and operated with virtual certainty of safety, yet at minimum cost.

The first member of the family, SPERT-I, began operation at the National Reactor Testing Station in July, 1955. SPERT-III began operation in December, 1958, and is now being used for the performance of transient tests under a wide variety of initial conditions of pressure, temperature and coolant flow of light water. A fourth reactor in the series, SPERT-IV, is now being designed. It will permit detailed studies on phenomena of instability demonstrated in some of the more than 1000 excursions conducted in SPERT-I. The tests in SPERT-I using a simple open-tank system, are generally characterised by sudden power rises that are arrested by inherent shut-down or self-limiting tendencies of the reactor itself. Without any external control rod manipulation, the reactor power reaches a peak in a fraction of a second and drops off to much lower but generally steady levels. In some cases, however, instabilities have been observed following the power peaks. Some of these are divergent oscillations that probably could destroy the reactor, despite its self-limiting characteristics, if allowed to continue. The precise causes of the self-limitation and power instabilities observed in SPERT-I are not known. In an effort to obtain a thorough understanding of these and other phenomena, the Commission authorised the long-range basic research programme to test and, if possible, to verify the major possible causes. This programme will require the continued operation of SPERT-I, together with SPERT-II, III and IV, and may entail still more additions to the family of reactors.

A series of nuclear physics measurements

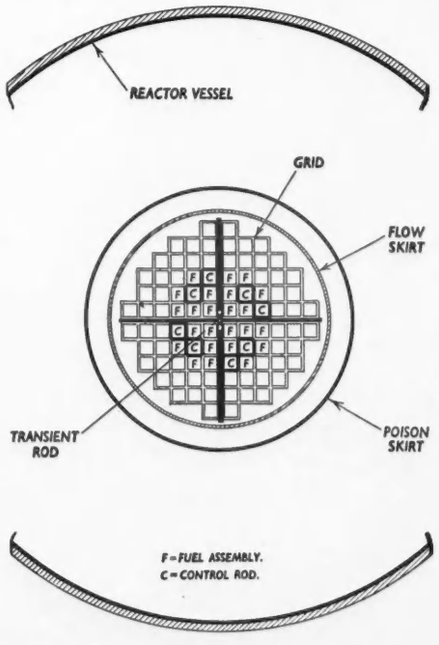


Fig. 1—Cross-sectional view of the reactor core taken on the centre-line

leading to a special programme of reactor hazards studies is the immediate operational aim for SPERT-II. The plant consists of a reactor vessel and coolant flow systems designed for operation with either light or heavy water at pressures up to 375 lb per square inch, temperatures up to 400 deg. Fah. and flow rates up to 20,000 gallons per minute. The coolant flow may be provided in either an upward or downward direction through the reactor core at velocities up to about 25ft per second to establish the desired initial conditions prior to transient testing of the reactor. No provision for continuous heat removal is included, however. The reactor and coolant systems are remotely operable, with the controls being situated in a control centre building approximately half a mile away from the reactor.

Reactor Design

The reactor assembly consists of the reactor core and structure, the control rods and drives, removable inner shells to control the reflector thickness and the reactor vessel. The arrangement of components enables reactor cores of varying diameters and heights to be inserted, and provides for varying thickness of either liquid or solid reflector to a maximum of 10ft overall diameter. The inlet and exit coolant piping is attached to the reactor vessel bottom head.

The reactor vessel (illustrated above) is a stainless-steel-clad, carbon steel vessel, 10ft i.d. by about 16ft high. The vessel is designed for a pressure of 375 lb per square inch gauge at 400 deg. Fah. and is equipped with a fully opening hemispherical head upon which is mounted a 42in diameter top plug containing the control rod drives. During normal shutdown operations only the top plug will be removed. The fully opening head may be removed, however, to change or remove inner shells, or to place solid reflector pieces around the core. The vessel bottom head contains a 42in diameter spool extending downward from the head. The spool is equipped with electric immersion heaters

THE AMERICAN SCENE *(Continued)*

having a capacity of 200kW for heating the moderator-coolant to the desired temperature, and it also contains a 24in coolant nozzle. In addition to the spool, the vessel bottom head is penetrated by four additional nozzles for the introduction or removal of the coolant, depending upon the desired direction of coolant flow through the core. Nozzles for the removal of instrument leads are provided in the top head and at several elevations around the vessel shell. In addition to the electric heaters in the bottom well, a further 400kW of heating capacity is supplied by side arm heaters in the vessel shell.

The reactor core and the removable inner shells are supported by an internal structure from the bottom of the vessel. A 42in diameter aluminium skirt surrounding the core directs the flow of the coolant through the core and separates the core from the remainder of the vessel to a height of about 4ft above the core. Coolant flow can be directed either upward or downward through the core, entering the bottom well and flowing either upward through the core, over the top of the core skirt, downward outside the core skirt, and discharging from the bottom of the vessel, or vice versa. To obtain the desired reflector thicknesses, using light or heavy water, a series of removable inner shells of different diameter can be installed. The shells contain a poison material which effectively establishes the reflector thickness by absorbing neutrons reaching the shell. Normally, only one shell of the desired diameter will be used at a time.

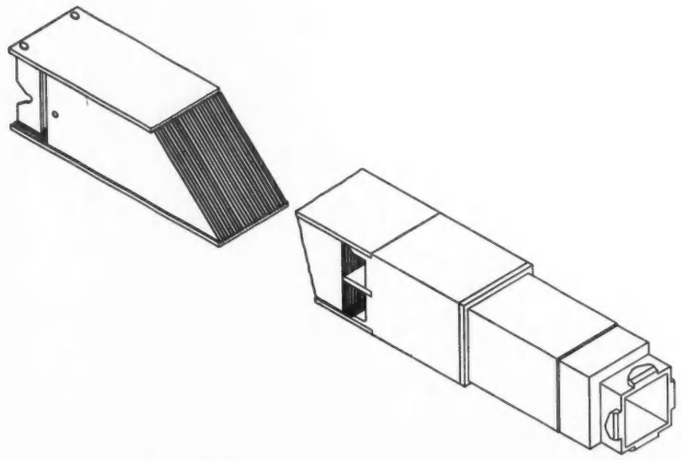


Fig. 2—Initial design of plate-type uranium-aluminium fuel element assembly

Low-pressure, non-flow tests using light water as a moderator and heavy water as a reflector, or vice versa, can be conducted by the use of a diaphragm extending from the top of the core skirt to the vessel shell. The diaphragm separates the two liquids by isolating the core region from the region outside the core skirt. The initial internal structure has been designed to accommodate plate-type, aluminium-clad fuel elements. Fig. 1 shows a cross-sectional view of the core taken on the reactor centre-line. It may be noted that a blade rod is situated in the geometrical centre of the reactor. This rod is the transient rod and contains poison in the bottom section. When the transient rod is ejected rapidly from the core, a sudden power excursion is initiated. Such tests are referred to as step transient tests. The four pairs of rods (*c* in Fig. 2) are the control rods. These rods provide the normal operating control and the means of initiating "ramp" tests when withdrawn at a fixed or an interrupted rate. Positions are provided in the reactor grid for a total of ninety-six fuel assemblies, including the fuel sections of the shim rods. The unoccupied fuel positions will be blocked during experiments requiring coolant flow.

Fuel and Control Assemblies

The initial design of fuel assembly to be used in the reactor is illustrated in Fig. 2. It is the same as that used in the SPERT-I reactor, thus permitting experimental correlation between the two reactors. The assembly is a plate-type uranium-aluminium unit containing four permanently brazed fuel plates and twenty removable fuel plates. The design of the assembly was developed for the specific purpose of determining the effect of plate spacing on reactor behaviour. With the full complement of twenty-four plates, the assembly contains 168 grammes of U-235, and the plate spacing is about $\frac{1}{16}$in. By removing every other plate, the unit will contain 84 grammes of U-235 and have a plate spacing of about $\frac{3}{16}$in. End box adapters, which mate with the lower support grid, are riveted to the lower end to complete the fuel assembly. Each fuel plate consists of a uranium-aluminium alloy core, 0·20in thick and clad on each surface with 6061 aluminium alloy, 0·020in thick. The active core height of the plates is 24in.

The control rods are fuel-poison rods, containing fuel in the lower section and a poison material in the upper section. Each pair of rods is joined by a yoke and driven by a single drive

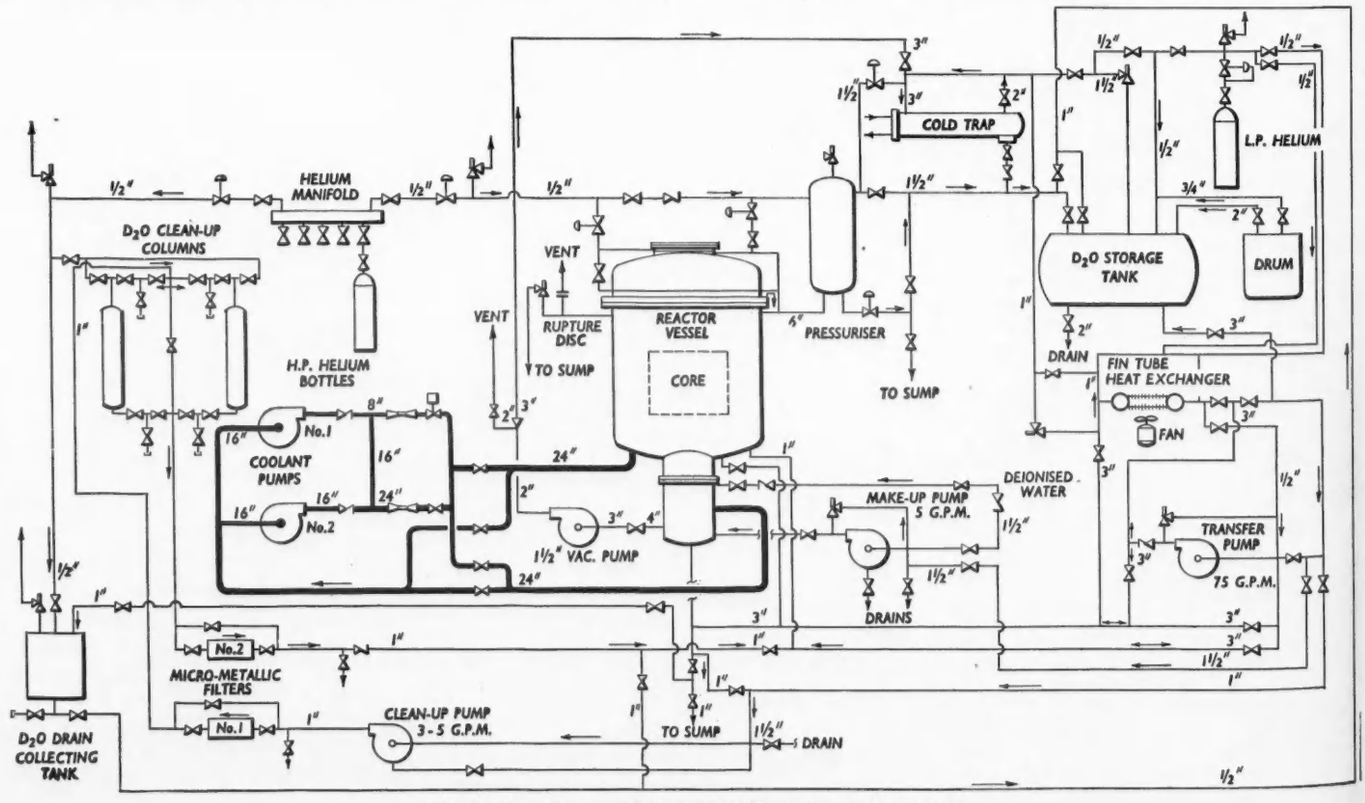


Fig. 3—Flow diagram of the SPERT-II reactor process system

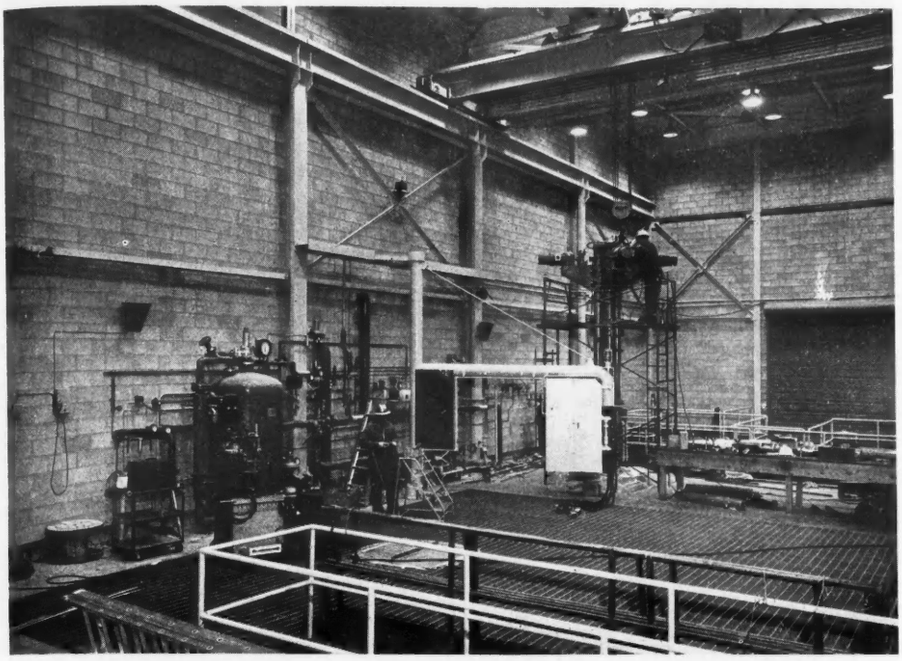


Fig. 4—Interior of the reactor building, showing the control rod drives

mechanism. In addition to providing the required control, this rod design was selected to minimise the number of drives, thereby providing greater flexibility for the removal of instrument leads from the reactor core. The fuel section of the rod is constructed to provide a variation in the number of fuel plates to agree with the number of plates used in the fuel assemblies. The poison section consists of a stainless steel box on to which an 0·020in layer of cadmium and an 0·040in layer of stainless steel has been sprayed.

Process Systems

A schematic flow diagram of the SPERT-II process system is shown in Fig. 3. The principal components are the primary circulating loop, a pressuriser vessel with a helium pressurising system, and a heavy water system. The primary coolant circulation loop is designed for use with either light or heavy water, and, by means of a cross-over, permits the circulation of coolant either upward or downward through the reactor core. The primary loop piping is made of 18-8 stainless steel and is designed to ensure maximum leak integrity and minimum holdup of the coolant. Where feasible, the valves have been placed in vertical runs to minimise liquid holdup. Generally speaking, when light water is in use in the reactor vessel and primary coolant loop, the heavy water system will be completely isolated from the loop by removable spools, and vice versa.

The two primary coolant pumps are conventional horizontal, single-stage, centrifugal pumps having a maximum capacity of 10,000 gallons per minute each and a net differential head of 175ft of water. The pumps are coupled to their electric motors through fluid drives. The fluid drives permit the adjustment of pump speed ; thus, the flow rate may be varied from 20,000 to 2000 gallons per minute. A further flow reduction down to 200 gallons per minute is permissible with an 8in flow control valve. The flow rate is obtained by either of two flow tubes designed to measure accurately the flow rate over the range of flows from 200 to 20,000 gallons per minute.

The reactor and coolant system are pressurised by means of the pressuriser vessel, utilising high-pressure helium. The pressuriser is directly connected to the reactor vessel and is mounted in relation to the reactor vessel approximately as shown in Fig. 3. In addition to system pressurisation, low-pressure helium will be used to purge and blow down the system as required. Helium released to the atmosphere for any purpose, such as de-pressurisation, will be first directed through a cold trap to recover any D_2O vapour from the helium.

The heavy-water system is composed of a number of small systems including the heavy-water storage vessel, a transfer system, a clean-up loop, and a D_2O recovery system. Heavy water is stored in a 14,500 gallon stainless steel-lined tank, which is provided with a helium gas blanket to a positive pressure of about 0·5in of water. Heavy water may be transferred from storage to the reactor vessel, or vice versa, by means of a 75 gallons per minute canned-motor pump. To cool the heavy water in the vessel below the boiling point before returning it to storage, or opening the vessel, a forced-draught, fin-tube heat exchanger has been incorporated in the transfer loop. The heat exchanger is capable of reducing the temperature of the D_2O from 400 deg. to 100 deg. Fah. in about twelve hours.

Heavy water purity is maintained by a clean-up loop consisting of a 5 gallons per minute canned-motor pump, two 35 micron stainless steel filters and two mixed-bed ion exchange columns. Heavy water situated in storage or in the primary system may be directed through the loop and returned as desired. The ion exchange columns contain about 1 cubic foot of mixed anion-cation resin each and are valved to facilitate removal without draining. The secondary equipment includes both pH and conductivity meters and a sampling station. The pH of the D_2O will be maintained at 6·5 to 7·0 and the resistivity at about 10^6 ohm-cm.

For experimental purposes, it is necessary to use light and heavy water alternately in the reactor vessel and coolant system. The possibility of contaminating heavy water with light water has necessitated that means be provided for thoroughly drying the vessel and coolant system. Drying will be done by placing the system under vacuum. A vacuum pump having an air displacement of 130 cubic feet per minute and capable of reducing the pressure to about 40 microns is included for this purpose.

Reactor Building

Fig. 4 is a general view of the reactor building, and Fig. 5 shows the reactor control room which is situated about half a mile away from the reactor. A reactor vessel and process equipment are situated in a leakproof pit. Access around the reactor vessel and the elevated process equipment is provided by platforms at two elevations surrounding the vessel. The fuel storage facilities include a miniature canal or hot storage well and a number of dry storage holes.

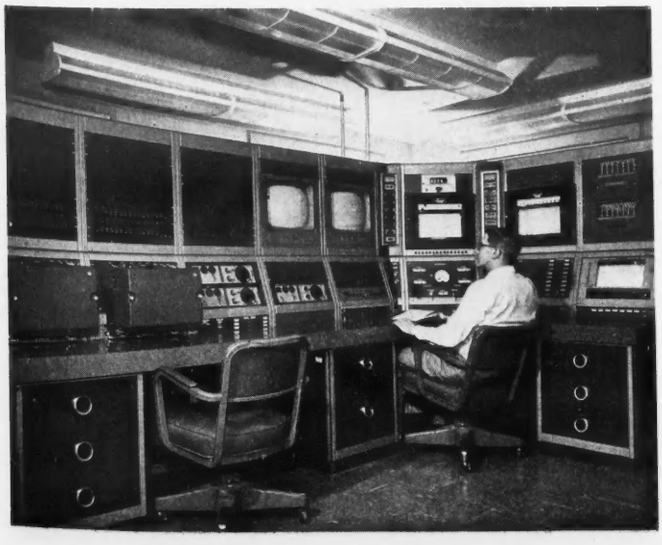


Fig. 5—Interior of reactor control room

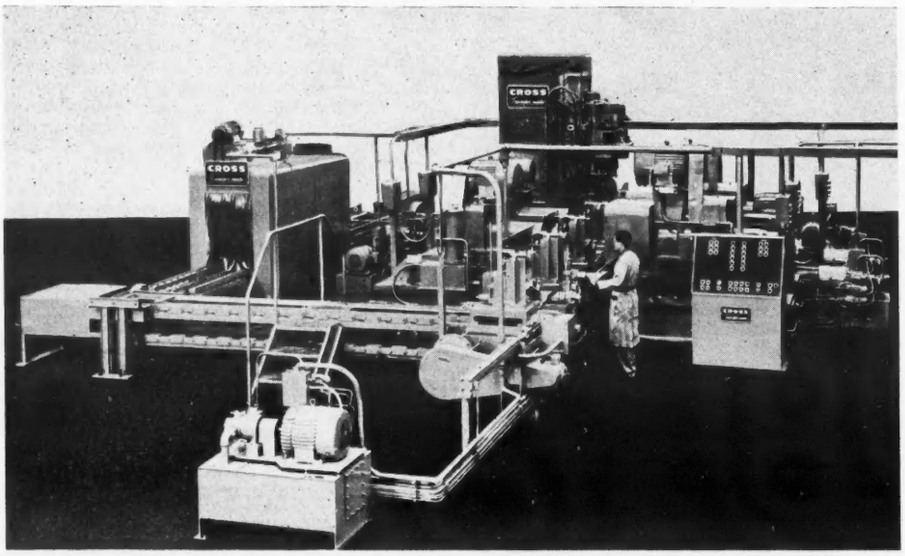
Transfer Machining of Tractor Rear Axle Housing

Four different sizes of tractor rear-axle housings are now being automatically processed in a way that ensures concentricity of the bearing seats, mounting flange and counter-bore, employing a " Transfer-matic " transfer machine, designed and built by the Cross Company, of Detroit, Michigan. The machine performs all the roughing operations in one station and all the precision finish boring and facing operations on both ends of the housings in another station, thus maintaining close alignment tolerances between the two ends. Each of the cutting tools in these two stations is separately adjustable. Another unusual design feature is the use of two heads and one bushing plate that index longitudinally so that successive feed strokes can drill and ream or tap accurate holes without moving the workpiece.

The grey iron castings from which the tractor rear-axle housings are produced have hardnesses ranging from 187 to 241 Brinell. Their bores are controlled to tolerances of ±0·001in. These holes are reamed to a size tolerance of 0·001in. During the design of the housings, the four different parts to be handled on the same transfer machine were given locating points in the same vertical planes, as measured from the back of the bells. Because of this, all parts can be accurately clamped in the same simple fixture-pallets with little adjustment between runs.

A workpiece is manually loaded and automatically clamped in the fixture-pallet at Station No. 1. A rotary transfer bar moves the pallet to succeeding stations. In the second station, three rough boring, one fixed facing and two chamfering cuts are taken in the smaller, back end of the workpiece ; and four rough boring, two

THE AMERICAN SCENE *(Continued)*



Transfer machine for tractor rear-axle housings with three machining stations, three chain conveyor and a wash booth

generating facing and two chamfering cuts are taken on the bell end. Similar but fewer finishing cuts are taken in the third station. In this station, both ends are precision bored and faced, maintaining close alignment tolerances between the two ends. The combination of the separately adjustable boring and facing cutters on two spindles effectively reduce the number of stations required in this " Transfer-matic " while increasing accuracy at the same time. The third and last machining station also contributed to a reduction in the initial cost of this transfer machine. All drilling, chamfering, reaming and tapping operations are accomplished by one vertical and one horizontal head in this station.

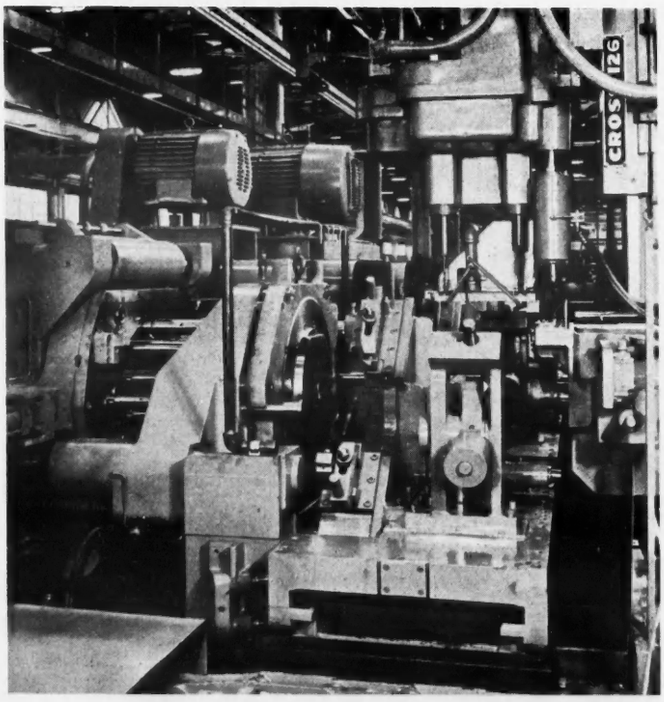
The vertical head, its bushing plate and the horizontal head are mounted on longitudinal " shuttles " so that successive passes can be made by different tools in the same holes without moving the workpiece. The floating bushing plate for the horizontal head does not index because it plugs into the chamfered main bore of the workpiece to maintain accurate location. Extra holes are provided in the bushing plate and clearance is provided in the fixture to accommodate non-cutting tools during the feed strokes of the head in its two positions. The horizontal head carries drills for all of the flange holes in the bell-end of the housing. After the holes have been drilled, the drills are withdrawn from the floating bushing plate, and the head is indexed sideways so that reamers can finish two dowel holes in the flange as the head feeds inward again. The vertical head feeds downward to drill two holes in the top of the workpiece. After the drills have been withdrawn, the head and bushing plate are indexed sideways so that the holes can be tapped as the head feeds downward again. There is clearance to avoid unused tools interfering on the alternating feed strokes.

Separately adjustable cutting tools are used for all boring and facing operations. The tool carriers are different for each of the workpieces but few different types of carbide blades are needed. The two generating facing tools are standard throw-away holders held in a single tool block. Many of the drills, taps and reamers can be used for more than one workpiece, which minimises tool changing between runs. The dowel holes are reamed with six-fluted straight, carbide reamers. In Station 4, the horizontal adjustable-spindle head is used with a different floating bushing plate for each housing. Only one bushing plate is required for the vertical head. The speeds and feeds stay the same for each part but the depths of cuts have to be adjusted by moving stops between part runs.

Automatic Bundling Machine for Billets and Wire Bars

A wide range of piercing billets, extrusion billets and wire bars in a variety of metals can now be packaged into uniformly shaped, tight bundles due to the development of a fully auto-bundling machine by the Loma Manufacturing Company of New York. The illustration below shows two representative machines in tandem designed to handle round billets up to 5in diameter and wire bars up to 4in square, in lengths up to 72in. The round billets are bundled in a hexagonal pattern, while the square wire bars are stacked in a square arrangement. The provision of two machines in tandem allows one bundle to be strapped, either manually or by power strappers, and discharged, while the next bundle is being built up in the other machine.

A powered roller conveyor feeds the billets to the bundling machine from such prior operations as casting, sawing, cupping, scalping or inspection. The individual billets are picked up by a lifter and are moved by loading levers into a transfer arm. The stroke of the transfer arm is determined by a signal obtained from the template which actuated the automatic programme control. Once the transfer arm travel stops, the loading levers are retracted and the billet drops into the cradle. The arm then returns and is ready to pick up the next billet, repeating the cycle. The entire bundling mechanism is subject to electro-hydraulic control and can be set for various billet sizes and stacking patterns by the exchange of templates within a few minutes.



(Above) Loma automatic bundling machine, showing completed hexagonal stack of thirty-seven copper billets

(Left) Third machining station of transfer line, with floating horizontal bushing plate and drilling, reaming and tapping units

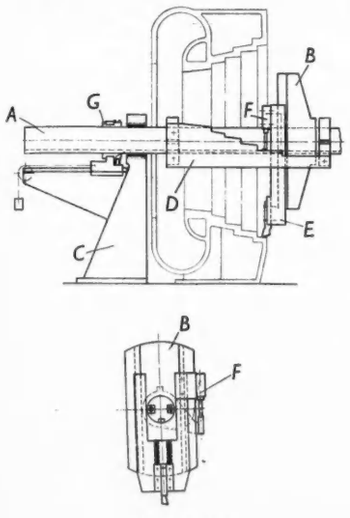
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

MACHINE TOOLS

839,046. July 4, 1957.—Bores of Hollow Bodies, Schiess Aktiengesellschaft, 289, Hansa-Allee, Dusseldorf-Oberkassel, Germany.

This invention relates to apparatus for profiling the bores of hollow bodies, particularly turbine housings, by the copying method. Referring to the drawing, the shaft *A* which carries the rotatable boring head *B* extends through the inside of the turbine housing and is supported at both ends of the workpiece in bearings, of which the left-hand bearing *C* is shown. On the boring head shaft beyond each end of the working stroke, are secured holders to which the pattern or template *D* is screwed so that it rotates with the shaft, and inside the workpiece. The



No. 839,046

boring head has a guide in which the toolholder slide *E* is mounted. There is also mounted on the tool slide a tracer device, the feeler *F* of which slides over the template during the movement of the boring head. An electric cable transmits the impulses of the finger through a slipring on a carrier *G*, (which is axially slidable along the boring head shaft and is rotatable with it) to the control devices for effecting the movement of the tool slide. In order to keep the transmission cable taut the slipring carrier co-operates with a block *H* slidable along a guide. This block through a weight hanging from a cord, or a similar compensating device, holds the cable under tension.—*June* 29, 1960.

AIRCRAFT

839,883. November 27, 1957.—Gas-Turbine Engines, Rolls-Royce, Ltd., Nightingale Road, Derby. (*Inventor: David Omri Davies.*)

In gas turbines it is known to utilise air compressed in a compressor system of the engine for cooling purposes or for sealing purposes in the engine. It will be appreciated that the abstraction of air from a compressor system reduces the overall efficiency of the engine, power having been supplied to the compressor system to compress the air thus abstracted. It is the primary object of the invention to provide a gas-turbine in which provision is made for tapping off air for such purposes from a compressor system of the engine in a manner permitting under some operating conditions at least a reduction in the loss associated with the tapping. According to the invention a gas-turbine has provision for abstracting air from a number of pressure locations in the compressor system, and there is provided control means to permit abstraction of air from a selected one of the pressure locations while preventing abstraction at the other pressure locations. The invention has an important application to aircraft engines and in such application there may be provided two tapping locations on a compressor system, one in the region of relatively low pressure and the second in a region of relatively high pressure. In connection with aircraft engines, two distinct advantages are claimed, one more particularly related to engines in low-speed aircraft, e.g. those having a flight speed less than the speed of sound, and the second in relation to engines in aircraft flying at speeds in excess of speed of sound. In the case of the low-speed aircraft the invention permits economy in the use of air tapped from the compressor system of the engine, in that under flight conditions a low pressure region of the compressor may be employed as a pressure source of cooling or sealing air whilst under ground-running conditions, under full power take-off and climb conditions of the engine a high-pressure region may be employed. In the case of the high-speed aircraft, the invention has an additional advantage in that it permits the use of air for cooling or sealing purposes which is at a suitable low temperature. The control means for selecting the location at which the air is abstracted from the compressor system may be manually or automatically actuated in accordance with a condition related to an operating variable of the engine itself or an operating variable associated with the flight of the aircraft. Thus for example change-over to abstraction of air through a low-pressure tapping from abstraction through a high-pressure tapping may be effected when the pressure at the high-pressure tapping reaches a predetermined value.—*June* 29, 1960.

BROACHES

839,708. September 24, 1958.—Multiple Tooth Broaches, Rolls-Royce, Ltd., Nightingale Road, Derby. (*Inventor: John Smedley.*)

This invention relates to multiple tooth broaches as used for slots such as the "Fir Tree" or "Christmas Tree" grooves for certain turbine rotor blades. In particular, it is concerned with broaches designed to cut such slots complete from root size by teeth which gradually approach the full size and ultimate contour. In conventional broaches both sides of the slot are cut simultaneously and then shaved individually by following sizing members if the broach teeth became worn. The chief object of the invention is to provide a broach which will avoid the use of following sizing members. A multiple toothed broach, which is illustrated in the specification, is split to form two broach sections arranged in tandem and staggered so that they come into operation successively, each section having teeth on one side only. The teeth on the two sections project in opposite directions, whereby the grooves or indentations on one side of the slot will be broached by the teeth of one section, and those on the opposite side of the slot broached by the teeth of the succeeding section. Each broach section is mounted for lateral adjustment to compensate for wear in the teeth. The two sections of the broach can each be keyed into broach holders in a normal manner, and the side of the broach opposite to the teeth can be cut back so as not to foul the slot. The two broach sections may be formed with individually detachable cutting elements. To adjust the broach sections laterally adjusting screws can be provided for individually adjusting the sections so that the overall width of the slot cut can be held within fine limits.—*June* 29, 1960.

AERONAUTICS

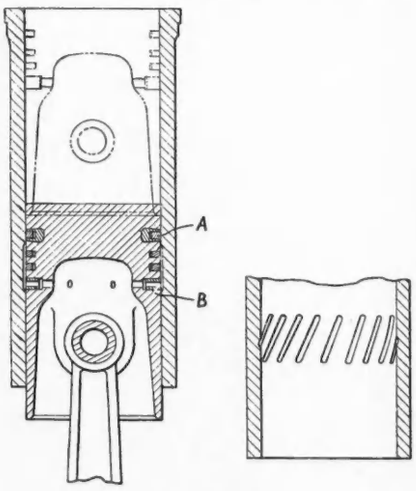
839,012. February 5, 1958.—Aircraft, Electro-Hydraulics, Ltd., Liverpool Road, Warrington, Lancashire. (*Inventors: Jack Perdue and Christopher Bernard Vere Neilson.*)

This invention concerns the distribution of the load carrying capacity over retractable landing gear and is particularly concerned with high-speed aircraft. The drawing accompanying the specification shows an aircraft with wings of low thickness/chord ratio which carry at their tips nacelles housing the power units. A nose under-carriage is retractable into the forward section of the fuselage and a main centre undercarriage is retractable into the fuselage centre section. Two outer undercarriages are mounted and retractable into the power unit nacelles located at the wing tips and are in transverse alignment with the centre undercarriage. This centre undercarriage is arranged to carry approximately 40 to 70 per cent of the aircraft static weight, whilst the nose undercarriage carries the conventional 10 per cent. The remaining static weight of 20 to 50 per cent is divided between the two wing tip undercarriages so that each carries between 10 to 25 per cent of the load. These undercarriages can either retract into the power unit nacelles, which are widely spaced with respect to one another, or can be folded flat into the wings. These outer undercarriages, although contributing only a small proportion of the landing energy, have two important functions. One is that, being equipped with brakes, they provide differential braking which stabilises the control of the aircraft on the runway, and the other is that they are designed to cater for a banked landing in such a way that any rolling tendency on the aeroplane can be fully damped out during an initial touch-down, without producing any impact loading on any of its load-carrying members. With such arrangements of undercarriage equipment, the aircraft can come in to land in a normal tail-down approach attitude which provides the advantage, which is lost by the bicycle type of undercarriage in that the effect that the tail-down attitude has in slowing down the aircraft during the early part of the landing run reduces the total length of runway required. The outer undercarriages may be arranged slightly aft or forward of the centre undercarriage and their disposition can be such that pitching and rolling effects of the aircraft on landing can be reduced to a minimum whilst the static wheel loads are properly balanced.—*June* 29, 1960.

INTERNAL COMBUSTION ENGINES

839,447. December 15, 1958.—Reducing Piston-Ring Groove Wear, Caterpillar Tractor Company, 800, Davis Street, San Leandro, California, United States of America.

This invention relates to the correction of excessive ring groove wear in internal combustion engines. As shown in the drawing a number of spaced grooves are formed in the wall of cylinder bore at a slight angle. These grooves are so positioned that when the piston is at the bottom of its stroke, the top edges register just below the compression ring *A*. The length of grooves is such that when the piston assumes the position shown, they extend down to a point just below the oil control ring *B* to provide vents for the



No. 839,447

escape of gases trapped between the intermediate rings and between the intermediate rings and the compression ring by way of a series of passages in the oil control ring and the piston. It is not intended to limit the configuration of the gas vent grooves in the cylinder; but when such grooves are at a slight helical angle it has been found that the ring grooves of the piston are kept relatively free of solid deposits. In addition, the helical grooves are beneficial in order that the gap of each ring moving in a straight line along the cylinder wall will cross the vent groove rather than register with it throughout the entire stroke.—*June* 29, 1960.

TUBE COUPLINGS

839,782. June 24, 1958.—Joints Between Tubes of Dissimilar Materials, United Kingdom Atomic Energy Authority, London. (*Inventors: Sydney Fawcett and William Rodwell.*)

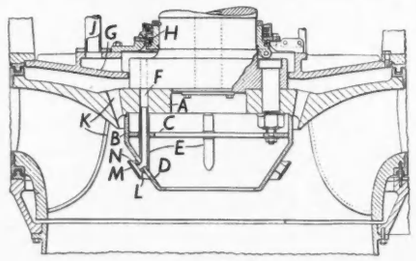
This invention is concerned with coupling tubes having different thermal expansion characteristics and of different diameter so that the tubes are brought together for coupling by passing the smaller tube through the larger tube. In this arrangement sealing is made between an internal flange on the larger tube and an external flange on the smaller tube. Such an arrangement is required in a sodium cooled graphite moderated nuclear reactor where the larger tube forms

part of the structure of the reactor and the smaller tube is a removable structural tube. Sealing between the flanges is effected by a metal ring and a problem exists in that the seal afforded by such an arrangement is unreliable when subjected to thermal cycling due to the different radial and longitudinal thermal expansion characteristics of the two tubes and the metal ring. According to the invention a tube coupling has a metal sealing ring located between an internal flange on the larger tube and an external flange on the smaller tube. This sealing ring is of material having a coefficient of thermal expansion intermediate between that of the larger and the smaller tubes, and includes a means of clamping. One embodiment of the invention is described by way of example in a drawing accompanying the specification.—*June* 29, 1960.

HYDRAULIC TURBINES

839,964. April 2, 1959.—HYDRAULIC TURBINES, Boving and Co., Ltd., 56, Kingsway, London, W.C.2. (*Inventor: Carl-Erik Stille.*)

This invention relates to hydraulic turbines of the mixed flow type and provides means for introducing air into the stream of water leaving the turbine runner and entering the suction pipe, with the objects of avoiding or reducing eddying, due to local reversal of flow in centrifugally-induced low-pressure areas near the axis of the stream, and, by the damping or cushioning effect of air incorporated into the stream, avoiding or reducing vibration. The invention is described, by way of example, with reference to the accompanying drawing which is a fragmentary axial section of the central part of a turbine to show the runner and noise-piece. Coaxially beneath the runner hub *A*, is an annular nose-piece comprising a shallow cylindrical ring *B*, an internal flange ring *C*, and a frusto-conical ring *D* with an inner peripheral bead ring. The nose-piece is secured to the runner hub by the flange ring held by nuts on studs screwed into the hub-holding bolts. In the nose-piece ring *D*,



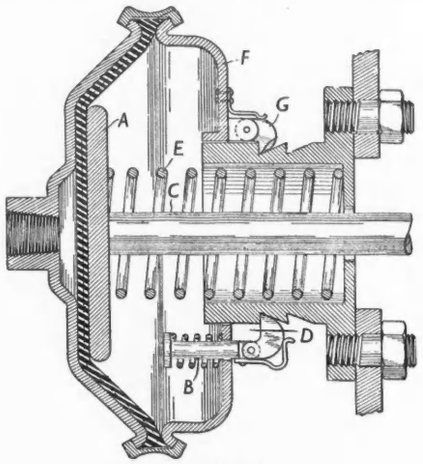
No. 839,964

there are four equiangularly spaced holes *N* from the inside of each of which an air-inlet pipe *E* leads straight upwards, through the flange ring, to aligned passages *F* through the runner hub and flanged bottom end of the shaft. The number of holes can be varied as necessary to suit particular turbine requirements. Above and around the flanged bottom end of the shaft an annular air space is defined by a runner cover *G* forming part of the turbine case and provided with a fluid seal against the shaft by a stuffing-box *H*. From above the runner cover, two main air-inlet pipes *J*, only one of which is shown, lead upward to an inlet duct having a control valve for admitting air. From the annular space beneath the runner cover, ports *K* in the runner hub lead to the water space around the nose-piece as is known practice. Each hole *N* in the nose-piece has a frusto conical boss *L* forming, with a frusto-conical cover plate ring *M* surrounding the nose-piece and common to all the holes, an air injector. When the turbine is running, water passes the holes *N* at a locally increased velocity and reduced pressure due to the throat or constriction between the respective boss *L* and the cover plate ring. This induces a pressure reduction in the atmospherically connected pipes *E* inside the nose-piece and thus causes inflow of air to the space around the nose-piece. The influx of air produces an increase of fluid pressure generally in the space, where local reversal of flow is otherwise liable to occur, and introduces into the water flowing through the suction pipe sufficient air to damp the transmission and propagation of vibration through the water.—*June* 29, 1960.

FLUID PRESSURE ACTUATORS

839,604. May 28, 1958.—AUTOMATICALLY ADJUSTED FLUID PRESSURE ACTUATOR, Bendix-Westinghouse Automotive Air Brake Company, 901, Cleveland Street, Elyria, Ohio, United States of America.

This invention relates to fluid pressure operated power actuators provided with means for automatically advancing the stroke or slack as the actuated member, such as a brake shoe lining, becomes worn. In operation, the actuator adjusts itself automatically to compensate for the wear through the action of the push-plate *A* being moved into contact with a series of plungers *B* when the actuator is energised. The plungers are of such a length that during early operation of the actuator, before the brake has become worn the plungers are moved only slightly by the push-plate in the direction of the push-rod *C*. As the brakes become worn the diaphragm, push-rod and plate move increasingly further to the right until the plungers *B* are moved sufficiently far that the latches *D* drop into the next succeeding notches on the fixed housing. Thereafter, when the pressure is released from the pressure side of the diaphragm it is moved with the push-rod and plate to the left by the return spring *E* away from the plungers *B* so that their springs expand against the inner face of the non-



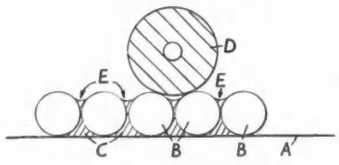
No. 839,604

pressure plate *F*. As the diaphragm and push-plate continue to move to the left the combined force of all the plunger springs in the direction of the actuated member exceeds the force of the return spring in the opposite direction. Thus the entire actuator housing moves to the right until the springs are expanded to their normal condition at which point the holding latches *G* move up over and drop into the next notch. When the actuator has been advanced as above described, the diaphragm push-plate and rod move relatively the same distance to the right as they did when the actuator was in its initial position before the member became worn. Now in the advanced position, the push-plate operates on the plungers exactly as it did before and as the actuated member continues to wear the plunger latches engage the next notch. Only two notches are shown in the drawing, but as many notches can be provided as desired so that the actuator can accommodate itself to the maximum extent that the actuated member may become worn and still operate as intended. It is preferable that the adjusting latches *D* carry none of the reaction load when air pressure is applied and that this load be borne entirely by the holding latches *G*.—*June* 29, 1960.

ELECTRICAL ENGINEERING

838,103. December 18, 1956.—IMPROVEMENTS IN VARIABLE VOLTAGE TRANSFORMERS, Foster Transformers, Ltd., South Wimbledon, London, S.W.19, and Robert Edward Jennings, 57, Pine Hill, Epsom, Surrey.

The present invention relates particularly to regulating transformers, parts of the windings of which are exposed for engagement by a contact brush or the like, the windings being either toroidal or of the straight-limb type, and the contact brush or the like moving in a circular, arcuate, or rectilinear path. With this type of transformer it is necessary to remove sufficient of the insulated covering of the wire forming the winding and also to remove a certain amount of metal from the wire to ensure that the brush, normally formed of carbon, has a sufficient contact area and bridges adjacent turns. It is sometimes preferable to use a brush in the form of a rotatable roller, particularly where the regulator transformer is immersed in oil, and under these conditions it may be found that the roller may rest on the insulation between the turns of the winding without contact with any of the conductor wires. The specification therefore describes an improved method of forming a brush track, applicable where a contact roller is employed, which avoids any serious reduction in the cross-section of the conductor wire and ensures that the contact brush or roller cannot occupy a position where it is not in contact with one of the conductor wires at least. One form of brush track according to the invention is shown in the accompanying drawing in which it is assumed that the winding is effected on a smooth flat surface *A* of toroidal or straight-limbed shape, the conductors *B* employed being preferably enamel-covered in the usual manner and held in position by coating or impregnation of the winding with a resin or lacquer, such resin being conveniently a polyester resin, and being allowed to harden after application. This coating is indicated at *C*; it surrounds the conductors and holds the turns firmly in position. After the formation of the winding the working track for the contact brush *D*, which may be a copper roller, or a carbon-faced roller, is formed by clean-



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ing the track surface by means of a rotating wire brush, the spindle of which is disposed at right angles to the direction of the conductor wires so that the direction of cutting is along the conductor. In forming the track the rotating wire brush is moved in the direction corresponding to the track to be formed. The insulating resin and the enamel covering of the wire if present are thus removed to form a series of depressions *E* between the turns but there is substantially no removal of the metal of the conductors themselves. The track obtained is thus of corrugated form as seen in section and consequently the contact roller moving over it always maintains contact with at least one of the conductors. —*June* 22, 1960.

Catalogues and Brochures

THE INCANDESCENT HEAT COMPANY, Ltd., Cornwall Road, Smethwick, Birmingham.—Leaflet No. V60 entitled "Jetube Vitreous Enamelling."

W. LANGLEY AND CO. (MECHANICAL HANDLING), Ltd., 14-16, Magdalen Street, London, S.E.1.—Illustrated brochure describing "Jacacaddy" lifting trucks. Details are given of a range of standard trucks, two- and four-wheeled, operated by hand, battery electric power, or mains electric power.

KEITH BLACKMAN, Ltd., Mill Mead Road, London, N.17.—Publication No. G.9 dealing with KB thermostatic control, both relay and direct acting types, for use in gas-fired installations to effect economies in fuel and time by automatically controlling the temperature of solids, liquids or air.

ELECTROTHERMAL ENGINEERING, Ltd., 270, Neville Road, London, E.7.—Second edition of the company's "Electronic Components" catalogue.

THE UNIVERSAL ASBESTOS MANUFACTURING COMPANY, Ltd., Tolpits, Watford, Hertfordshire.—Product catalogue for the Universal Magnum sheet in asbestos cement, providing full technical information on fittings and accessories required for use in design, specification and fixing.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH INTERPLANETARY SOCIETY

Mon. to Sat., Aug. 15 *to* 20.—Royal Institute of Technology, Stockholm, Sweden, Eleventh International Astronautical Congress.

INSTITUTE OF METALS

Mon., July 25.—Royal Institution, Albemarle Street, London, W.1, "The Structure of Metals and Intermetallic Compounds," Linus Pauling, 6.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day to Wed., July 22 *to* 27.—ELECTRONIC AND COMMUNICATIONS SECTION: Olympia, London, W.14, Third International Conference on Medical Electronics, in association with the International Federation for Medical Electronics.

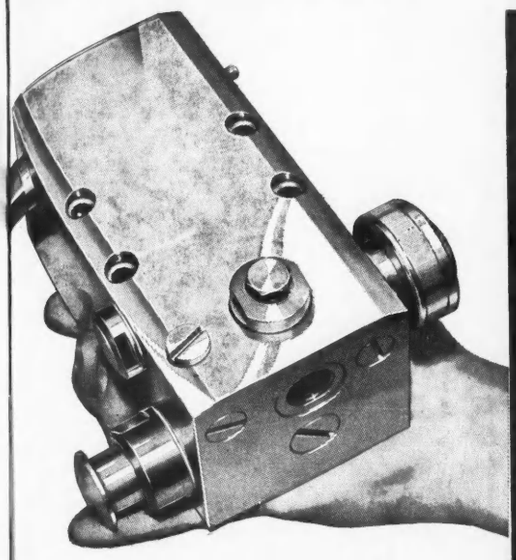
ROYAL INSTITUTION OF CHARTERED SURVEYORS

Tues., Aug. 30, *to Sat., Sept.* 3.—The University College of North Wales, Bangor, Annual Conference, 1960.

Advanced Engineering Courses

Production Engineering. IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, South Kensington, London, S.W.7. A full-time course in production-engineering commencing in October. The course will be of one year's duration and successful candidates will be awarded the D.I.C. Students will be required to take three compulsory subjects: Industrial engineering; management and industrial administration, and statistics and statistical methods. Prospective entrants should possess a degree or equivalent, together with some practical experience.

Production Planning and Control. UNIVERSITY OF BIRMINGHAM, Institute for Engineering Production, "Southfield," 16, Norfolk Road, Edgbaston, Birmingham, 15. Residential executive course, September 19 to 30. The primary aim of the course is to discuss methods of production planning and control and the application of systematic analysis to these functions with a view to the improvement or organisational and production efficiency. The course is intended for industrial executives, senior production engineers and controllers, O. and M. personnel and other specialists in related fields. Fee sixty guineas.



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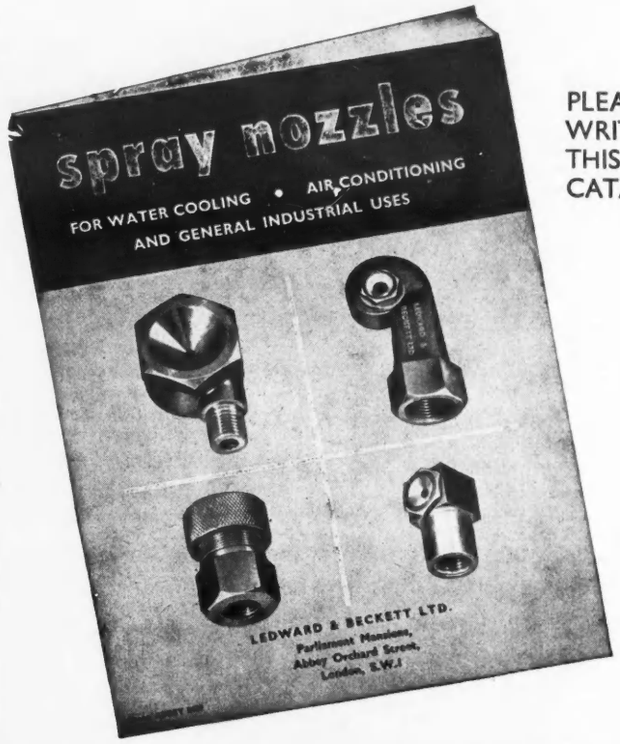

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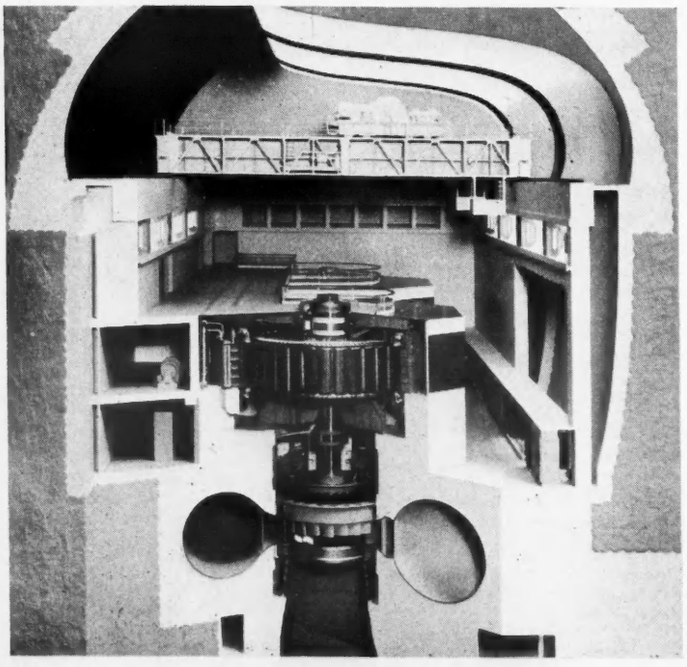

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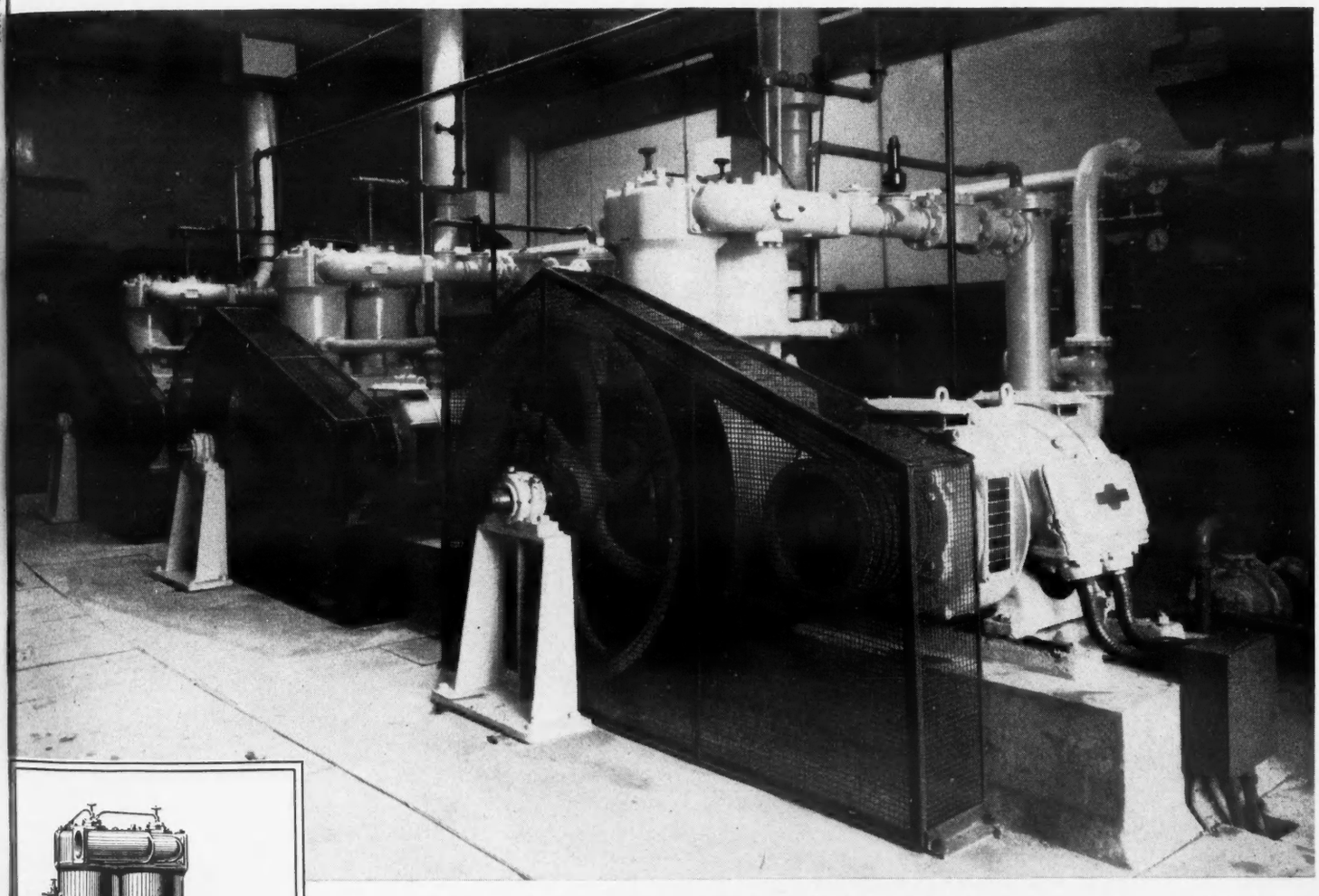

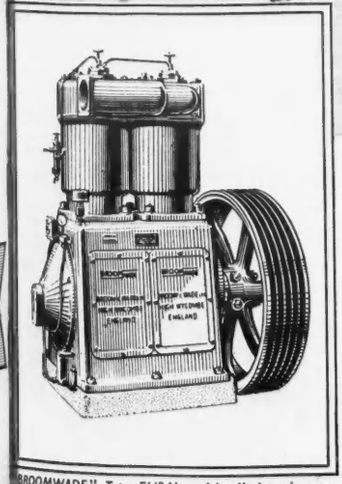

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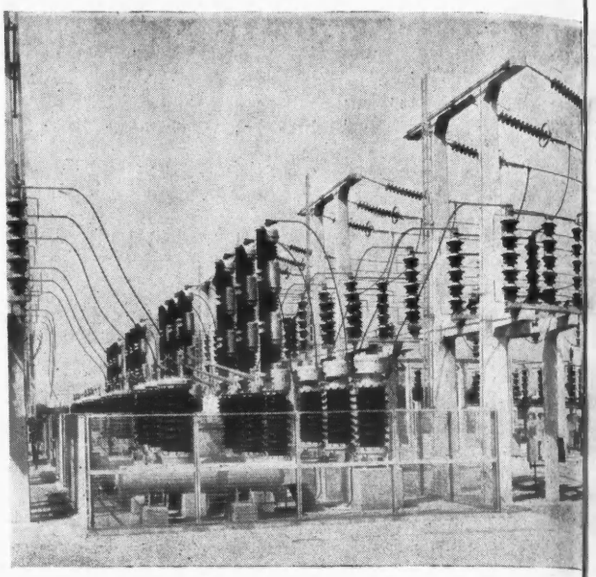

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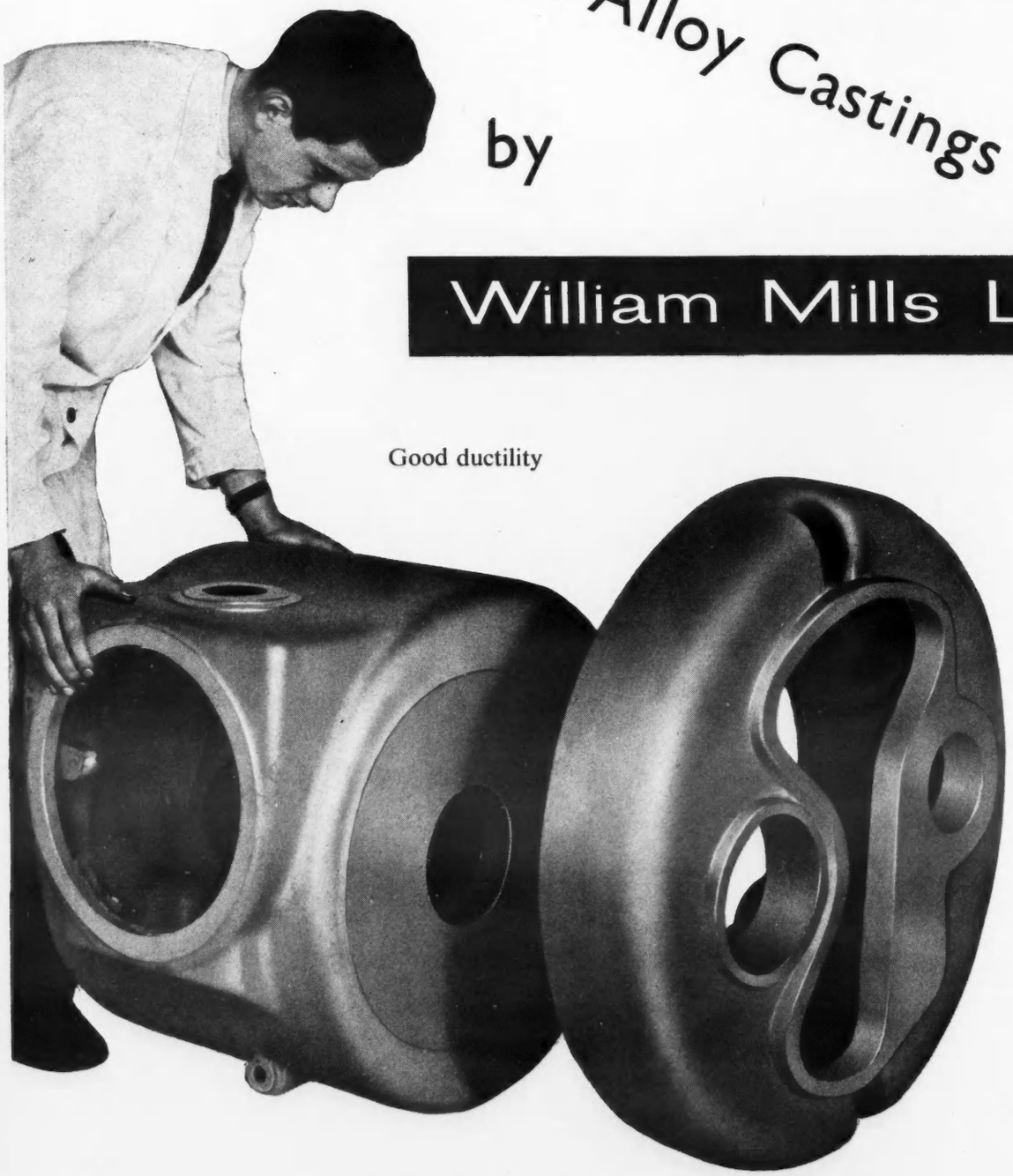

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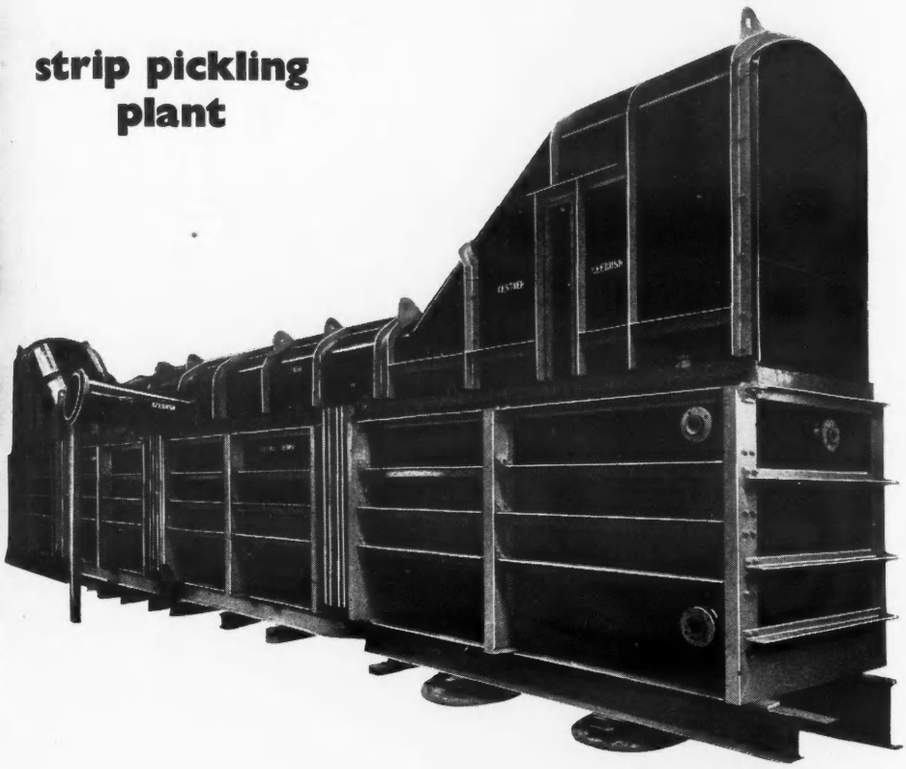
strip pickling plant



Kestner

The Kestner organisation has a wealth of experience in pickling processes for all industries. We are able to advise you on all your problems. The illustration shows a large strip pickling tank fabricated in Keebush incorporated in a steel strip pickling section that we are supplying to a very large and well-known steel manufacturer in this country.
Keebush, the well-known corrosion resistant plastic constructional material, is used wherever possible for plant handling corrosive liquors.

Complete pickling plant by Kestners includes :

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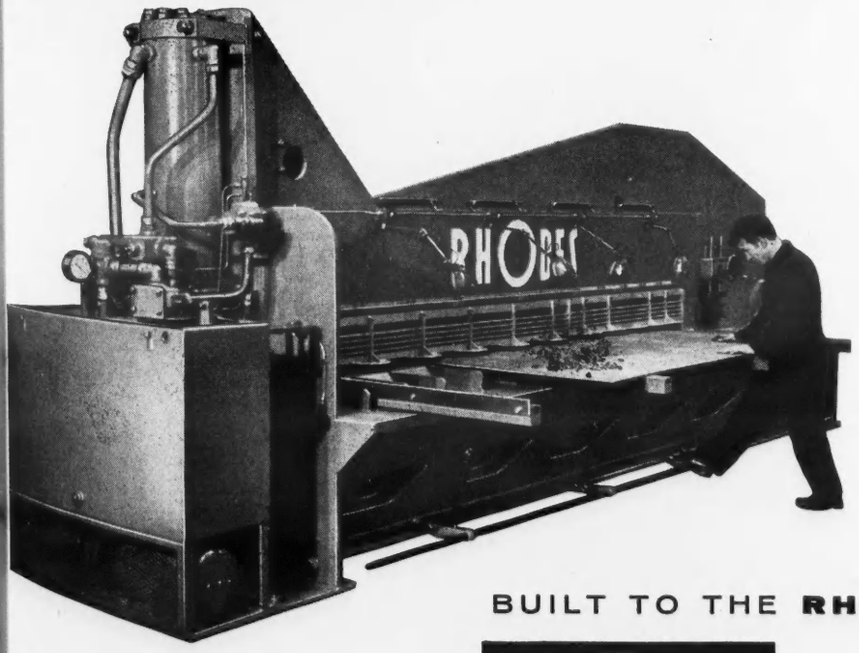
this isn't a 'gimmick'
it's a Shear necessity



...Does work of 5 machines. Costs less than 1.

It seems to have become a habit to describe any new machine as "Revolutionary" —the word has lost its meaning— and most of these so-called revolutionary machines are the same old designs with a gimmick tagged on to them. This puts us in a quandary. For how else should we describe the Hydraversal Shears? It does the work of 5 machines, costs less than one. You can get rid of your plate shears, cropping shears, trimming shears, billet shears, slab shears — the Hydraversal will do all their jobs better than they did it themselves. Trim a sheet or crop a billet—without adjustment. You can't break it. The secret is the patented "reverse-scissor" action. Revolutionary? Just a gimmick? Or, as we believe, a matter of intelligent simplification? Plus know-how—136 years of it.

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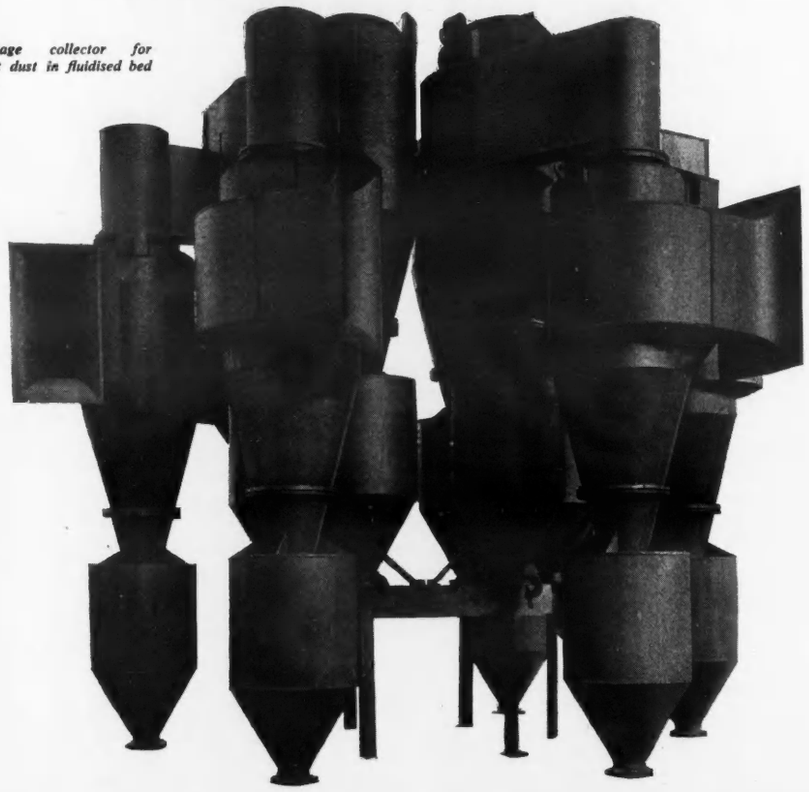

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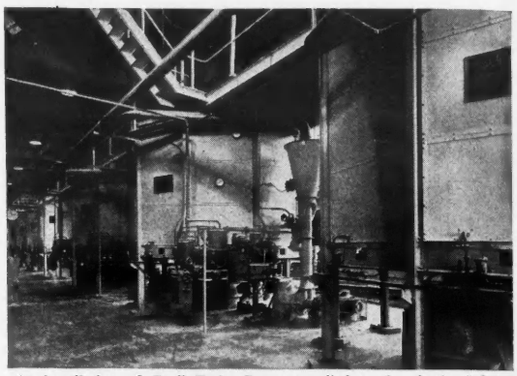
We design and supply complete dust separation plants incorporating Buell high-efficiency cyclones (Van Tongeren System). Also complete installation for the economical and efficient drying of material, incorporating Buell (Büttner) Rotary Drum or 'Turbo' Tray Dryers. Full information in our leaflets - "Drying Equipment" and "Dust Collection".



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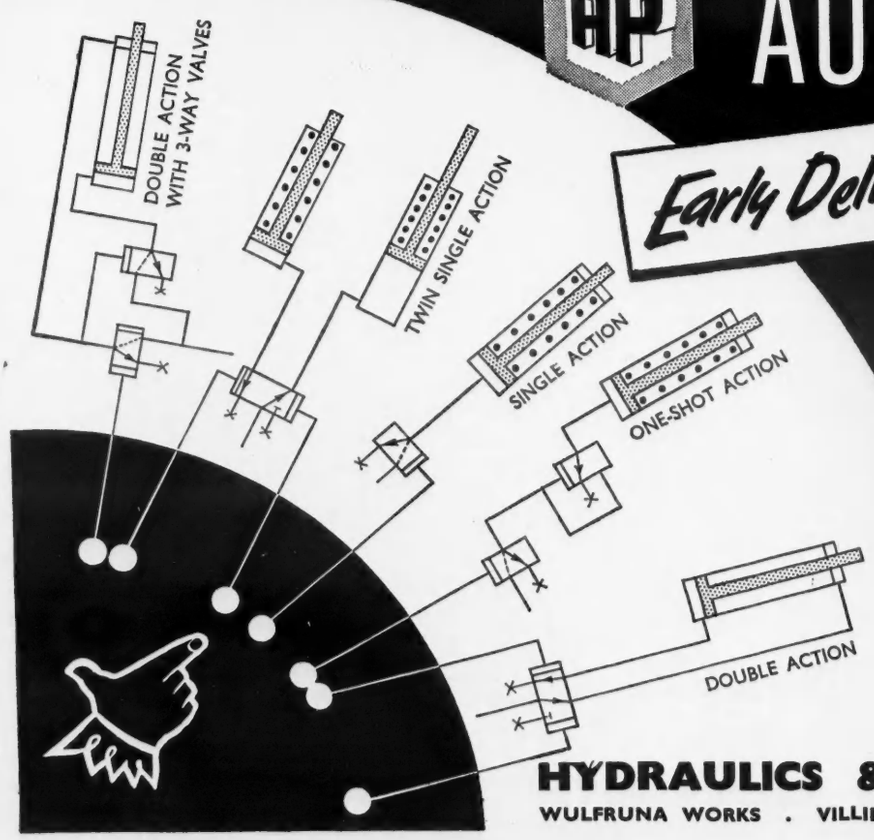

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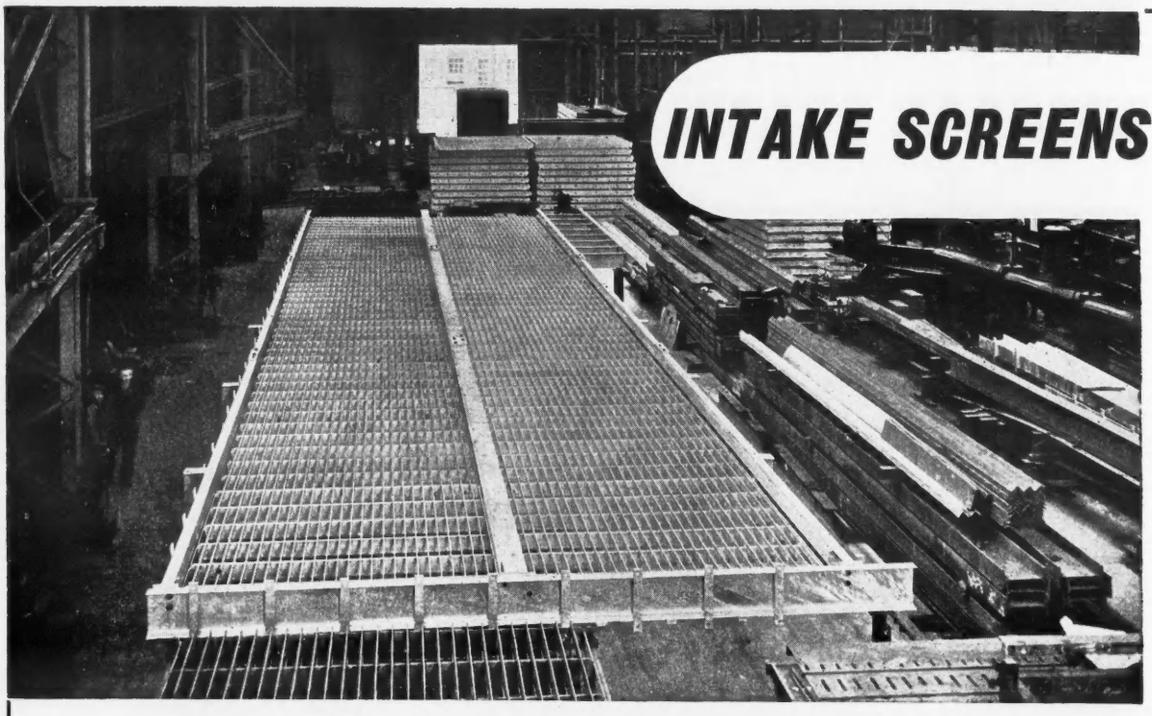

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Section of the intake screens for the Roxburgh Hydro-Electric Power Project, New Zealand. Manufactured by Joseph Westwood & Co. Ltd. for the main contractors, Holland and Hannen and Cubitts (N.Z.) Ltd., and S.A. Conrad Zschokke, Geneva, and Downer & Co., Ltd., Wellington, who are building the Project to the design of the New Zealand Ministry of Works.

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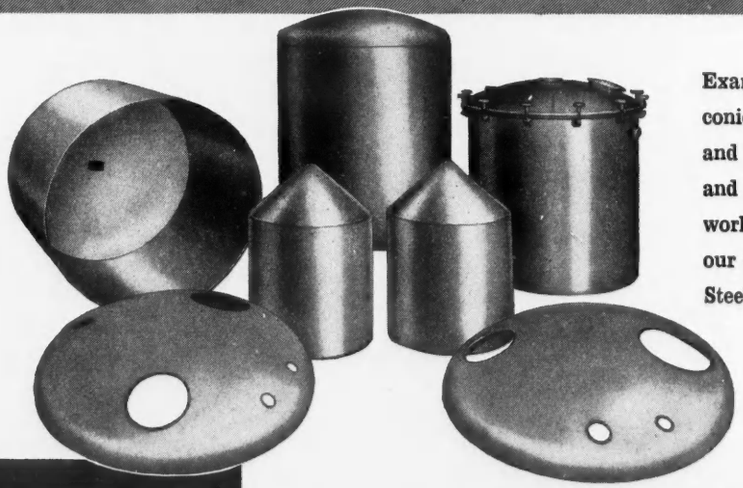

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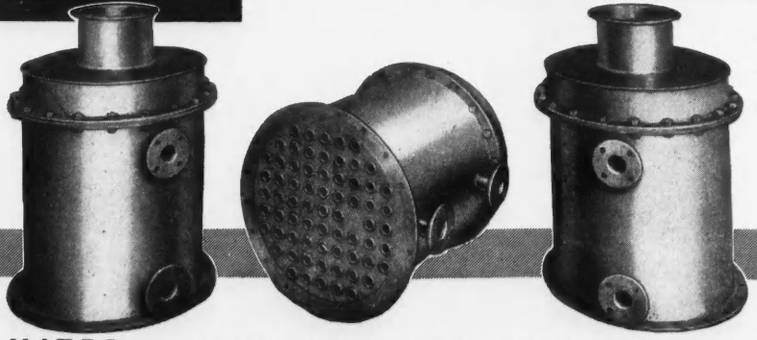

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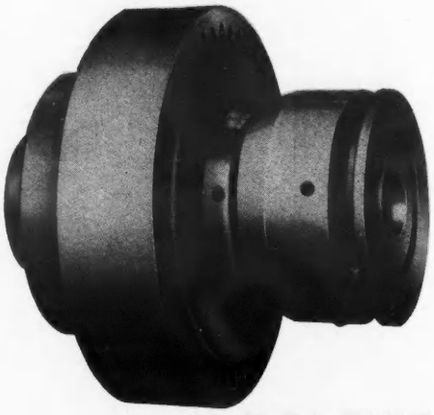
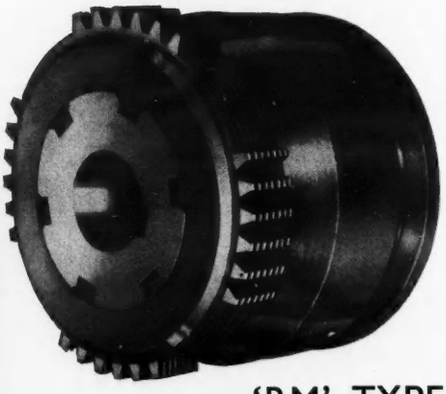


'RO' TYPE



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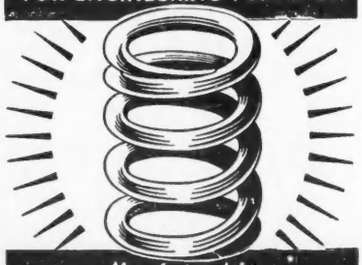

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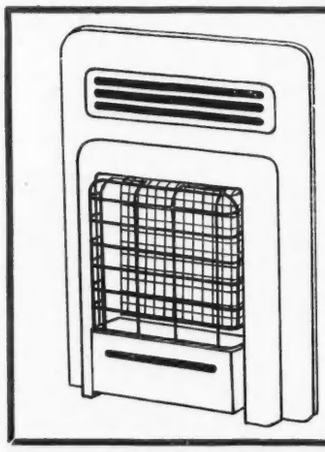

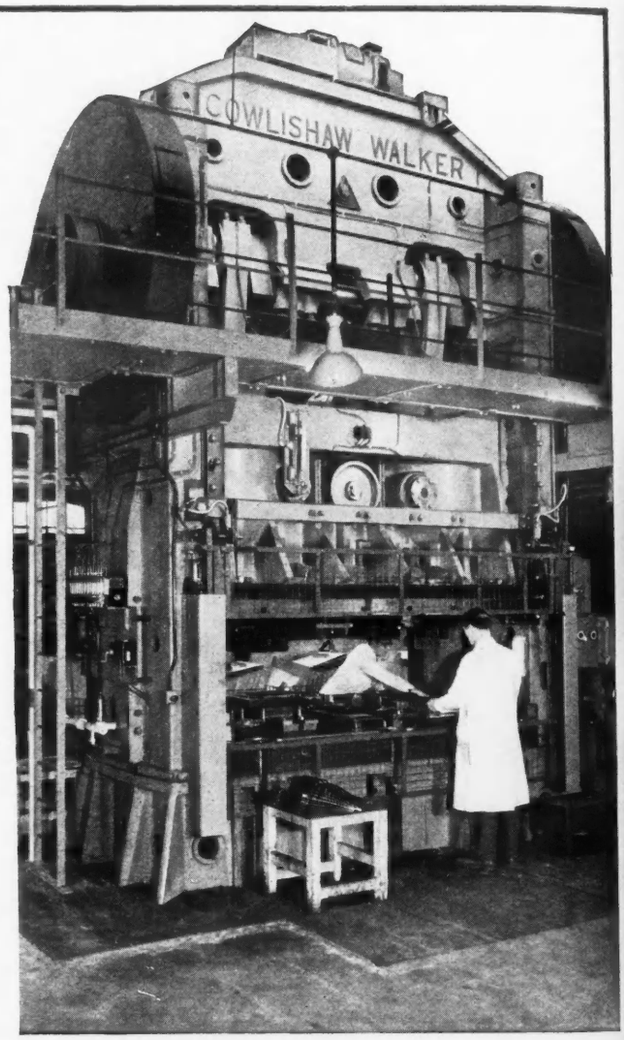

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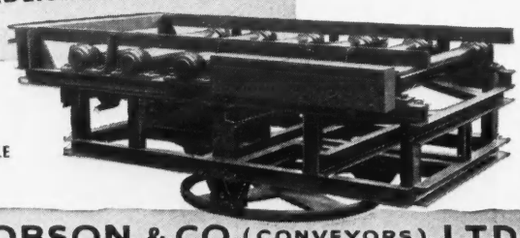

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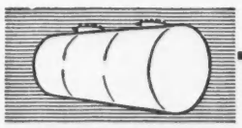

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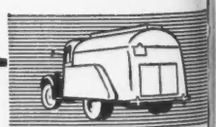

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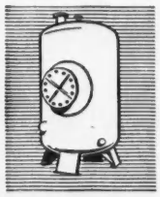

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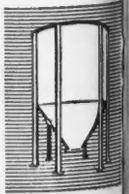

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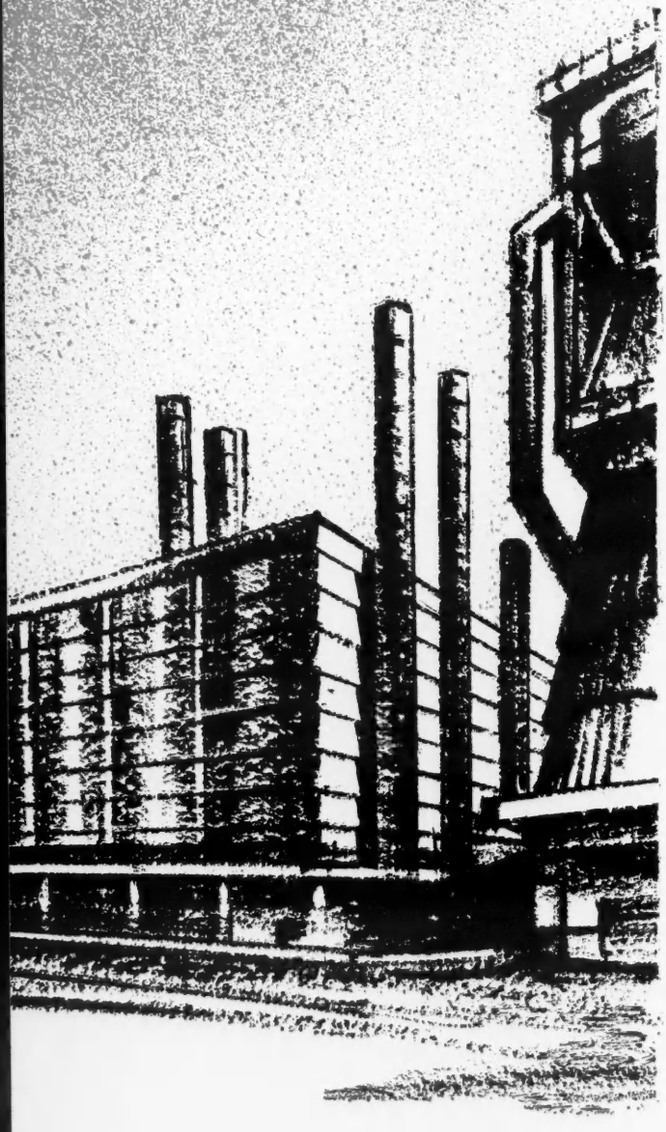

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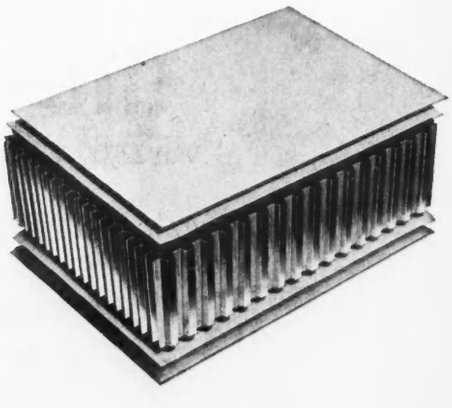

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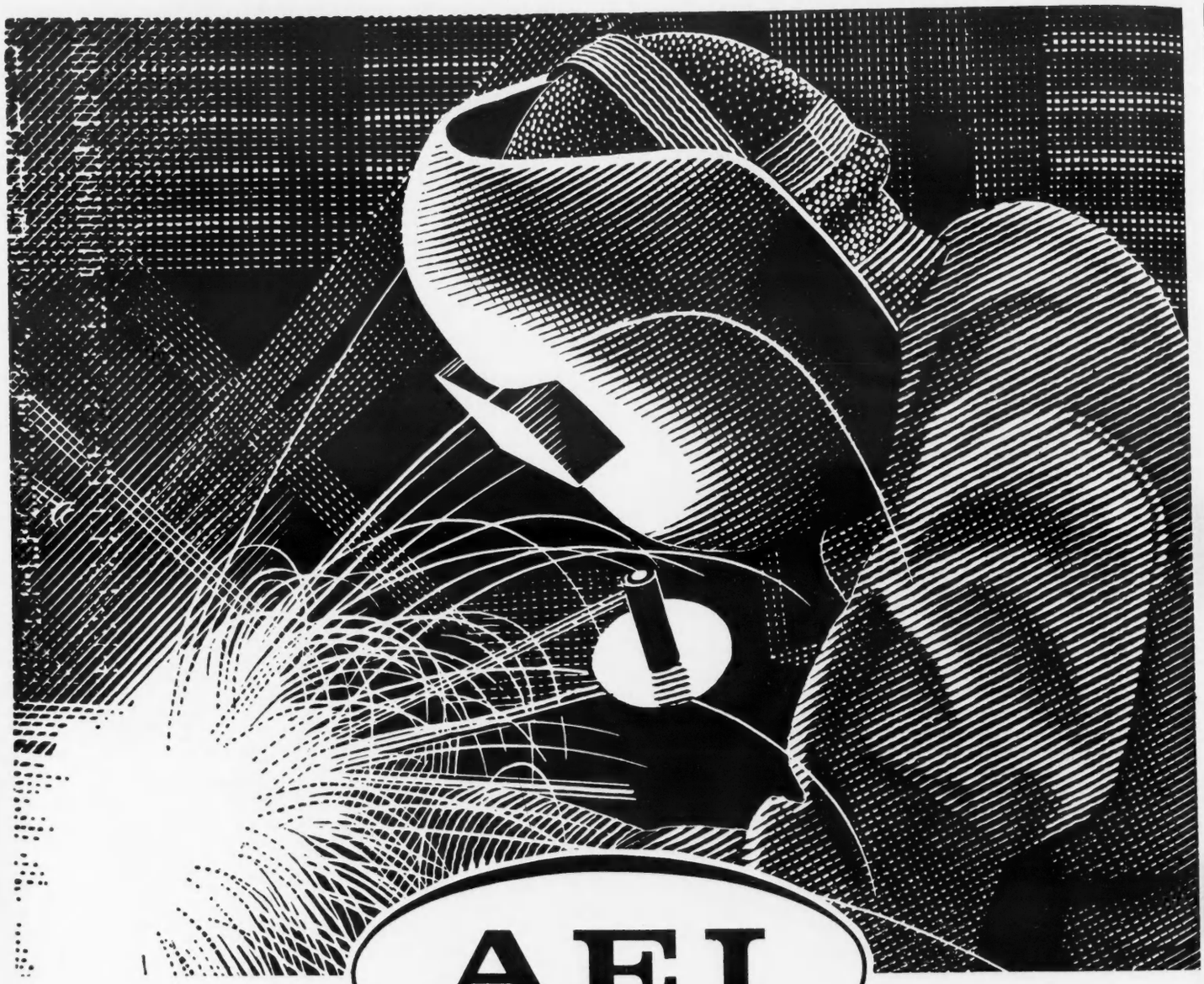

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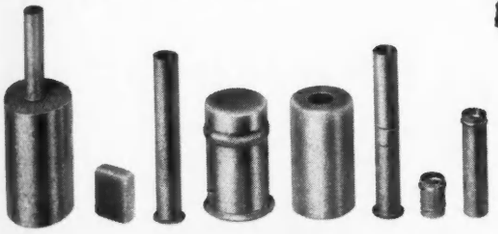

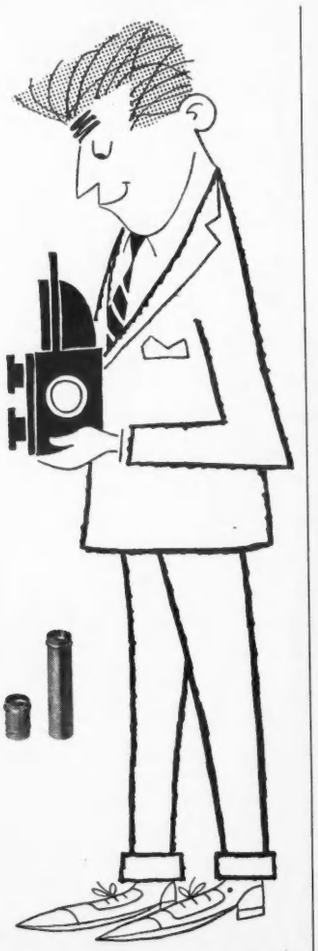

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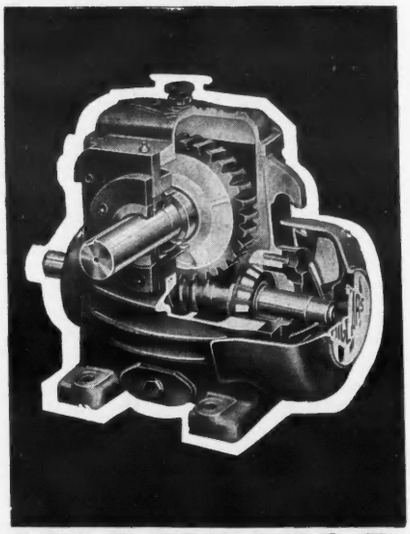

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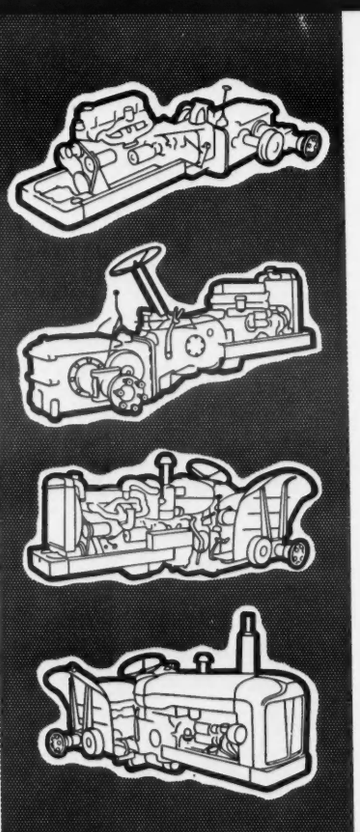

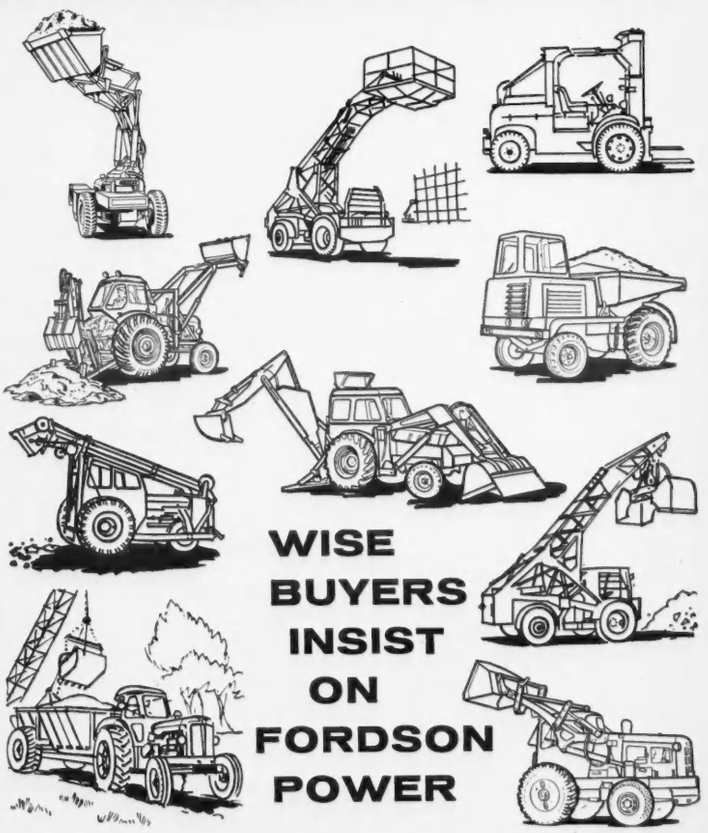

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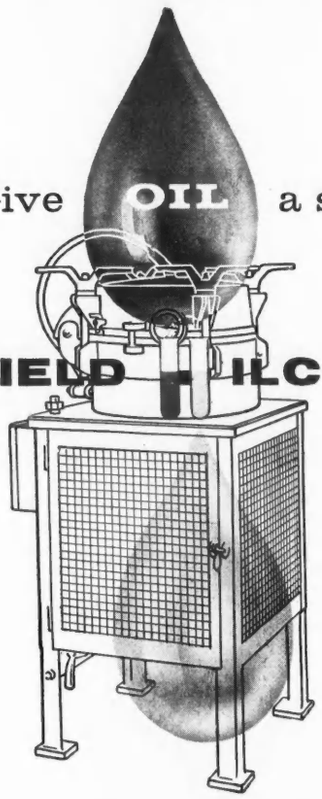

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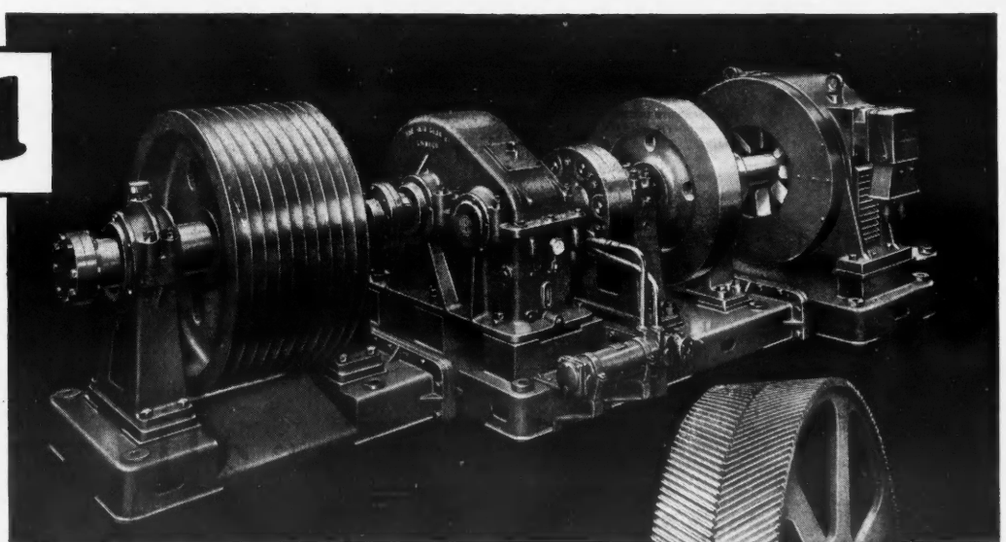

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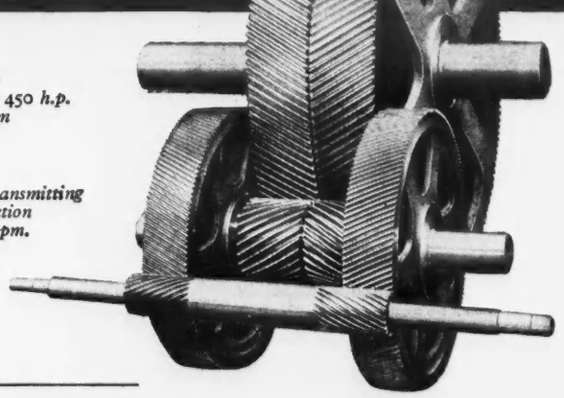

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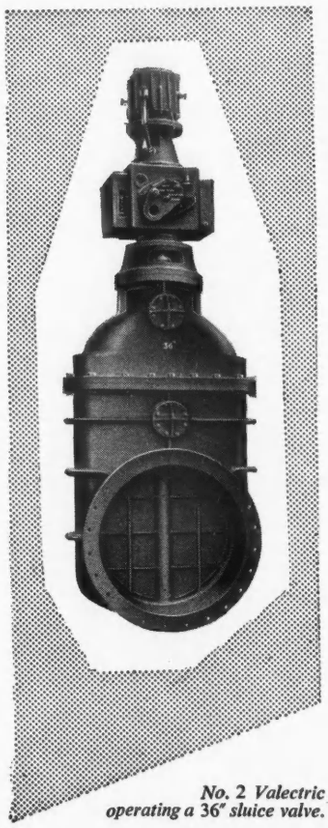

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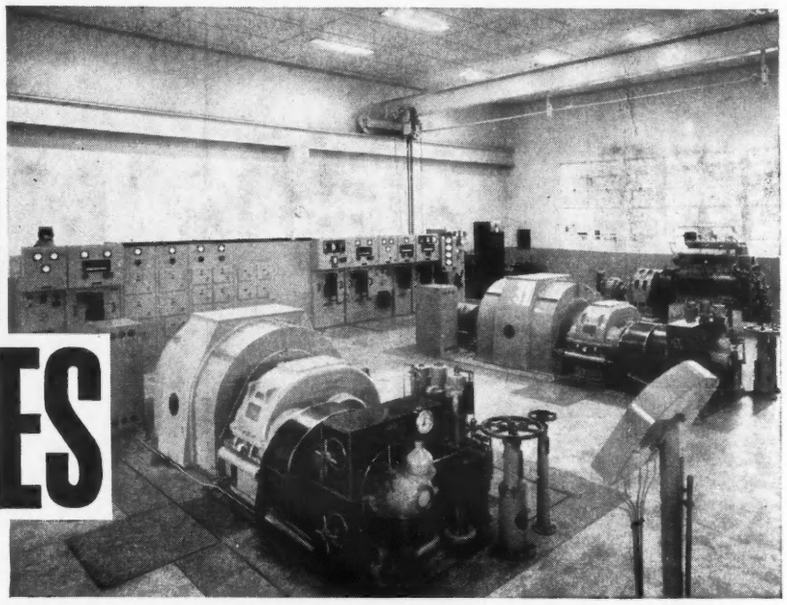

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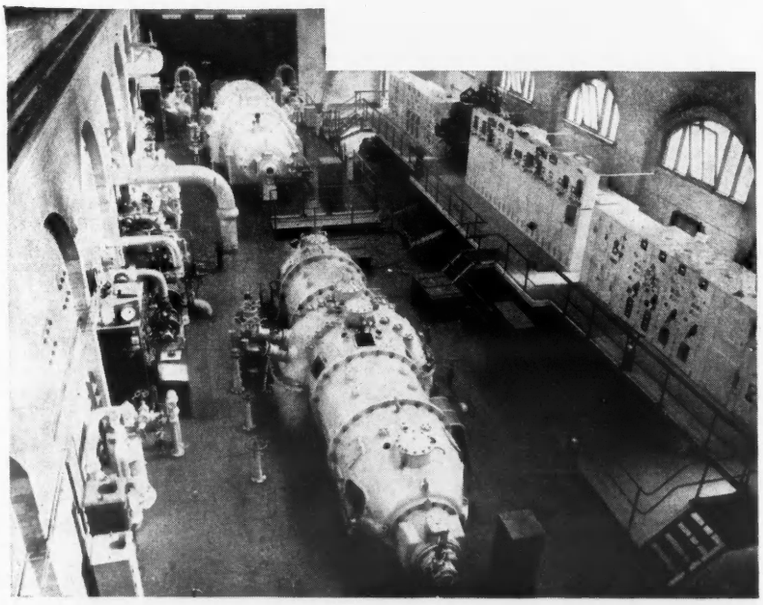

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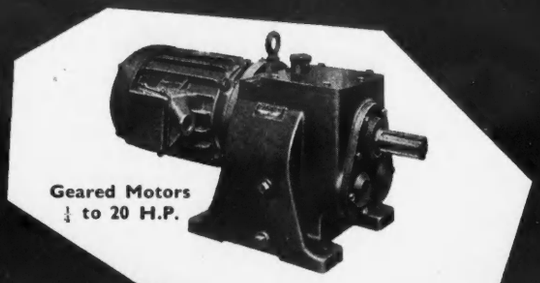

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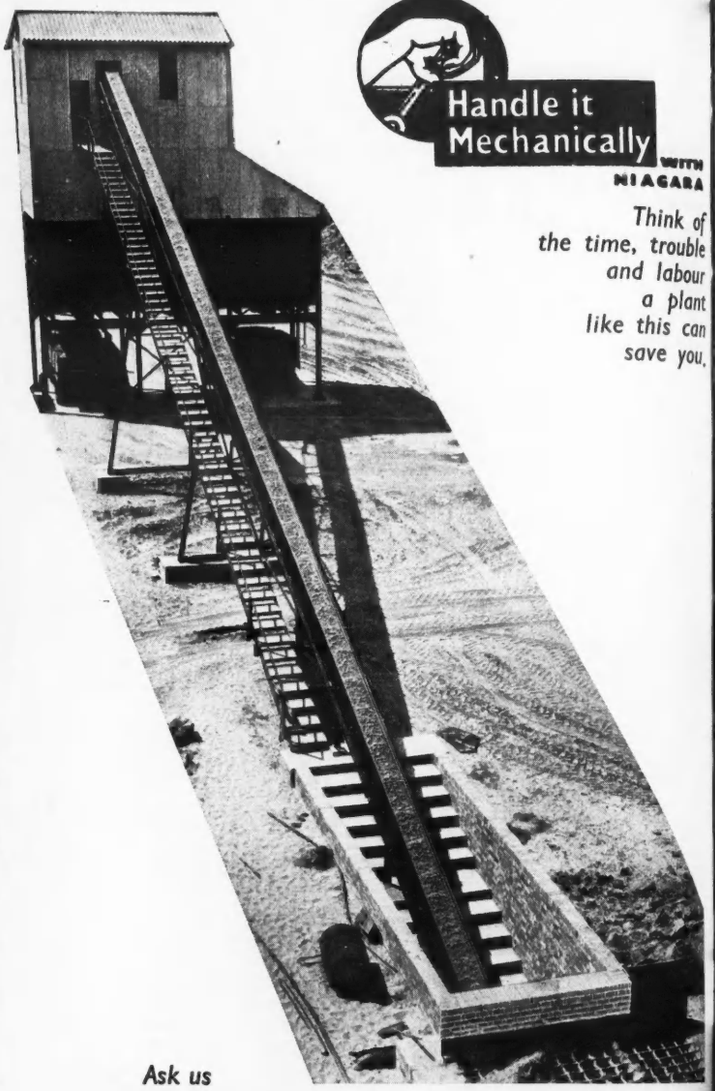

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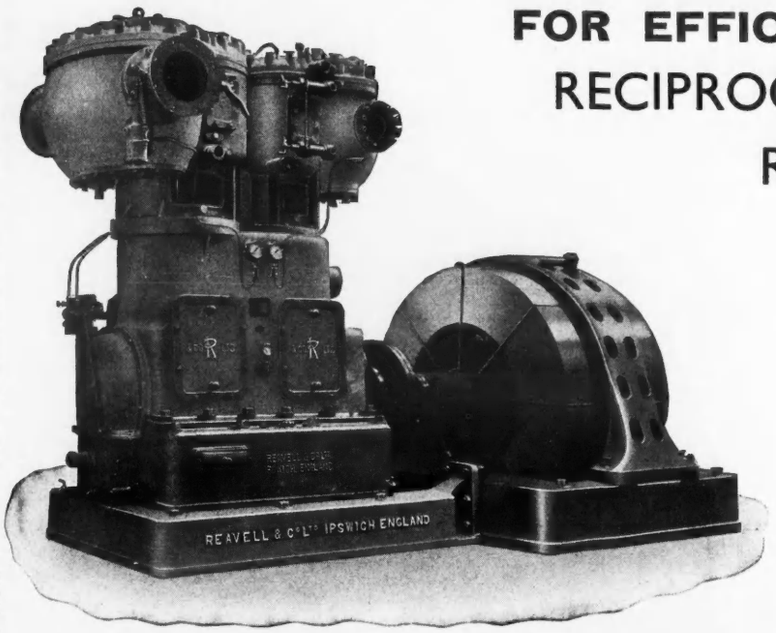

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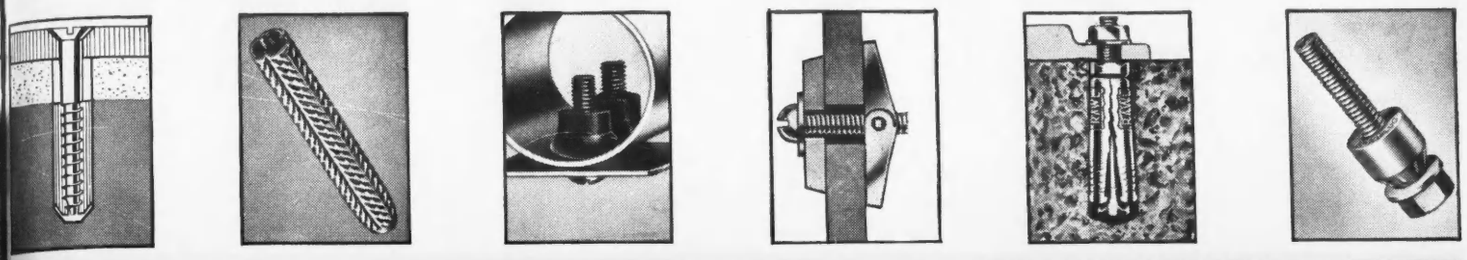

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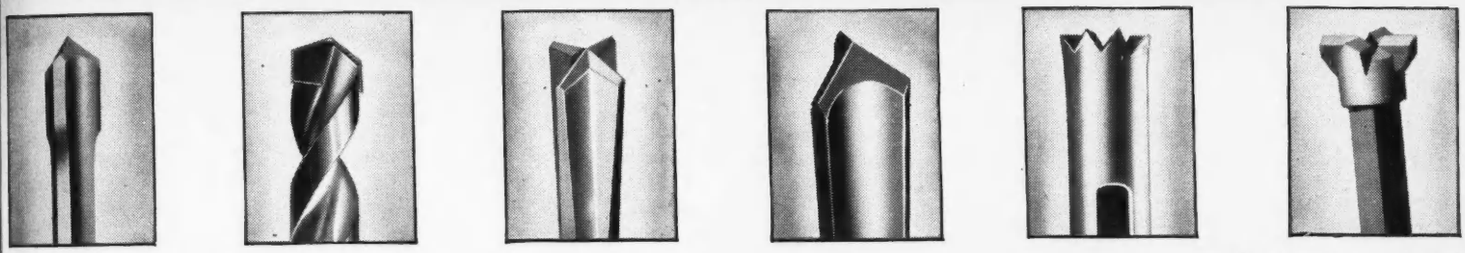

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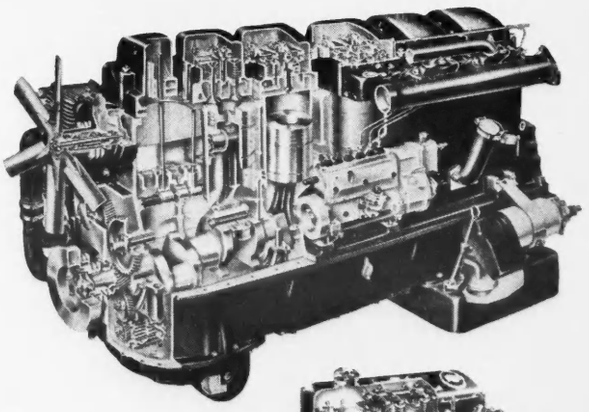

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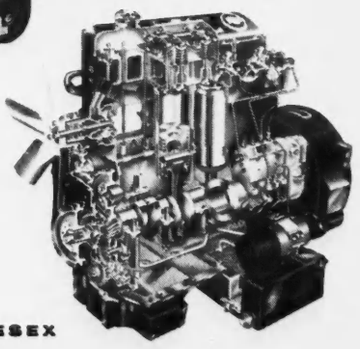

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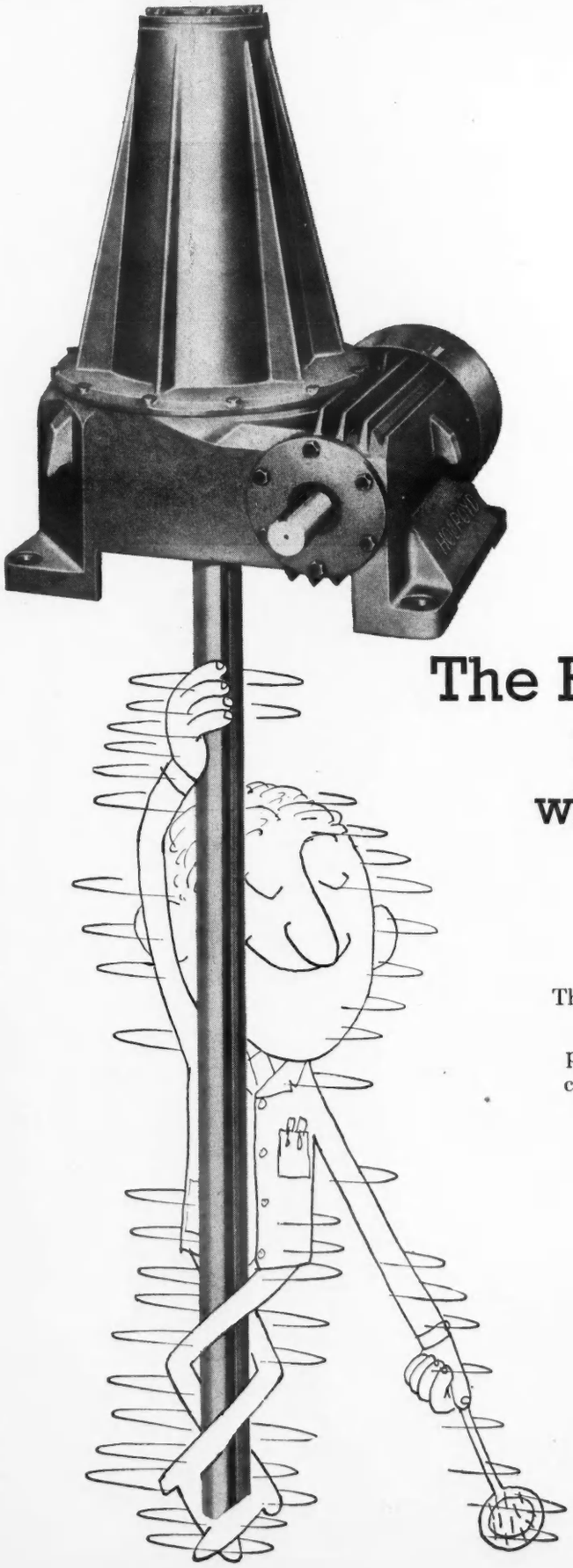

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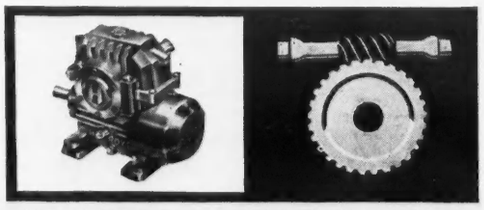

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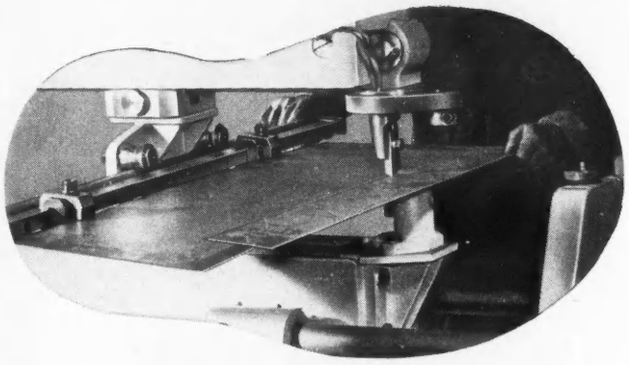

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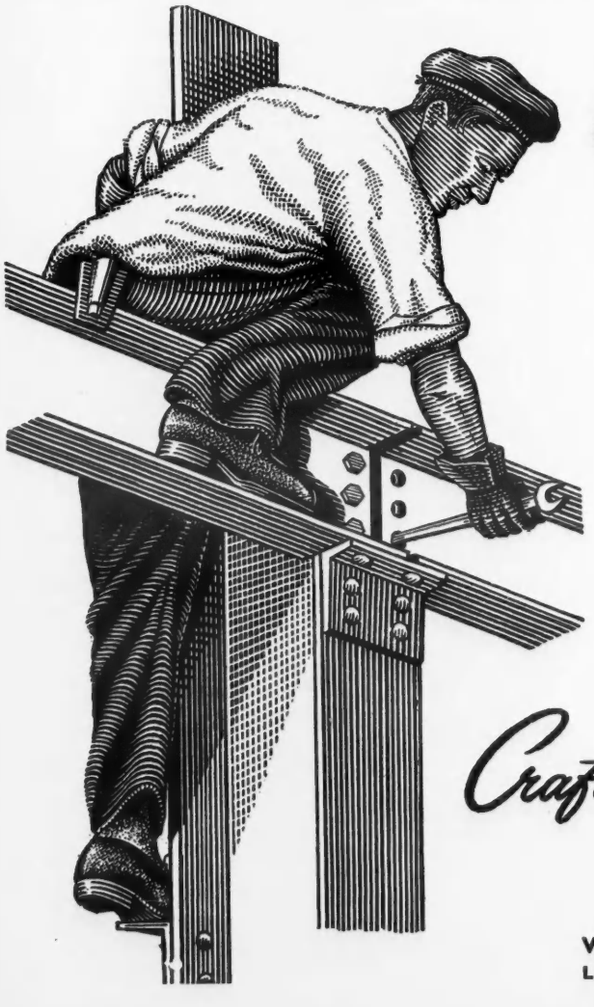

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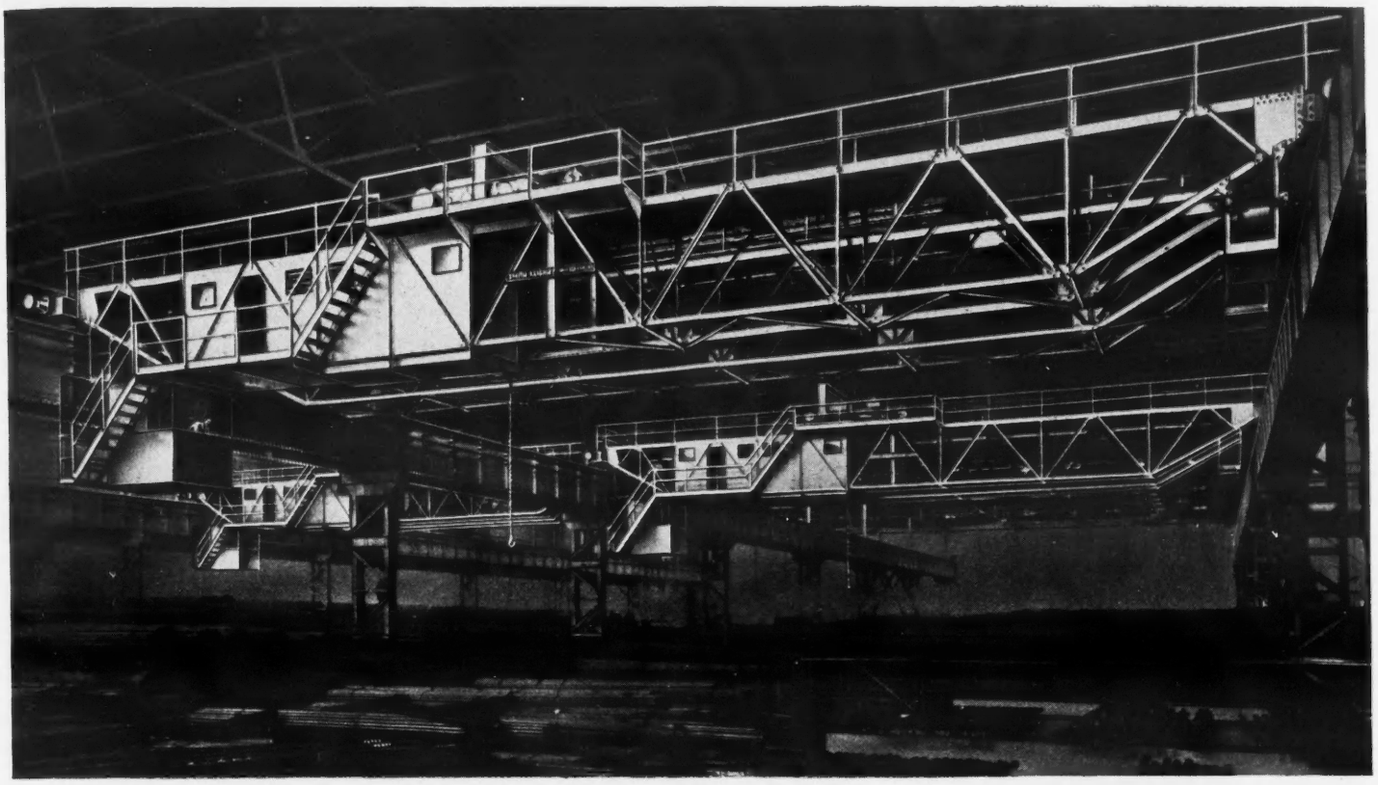

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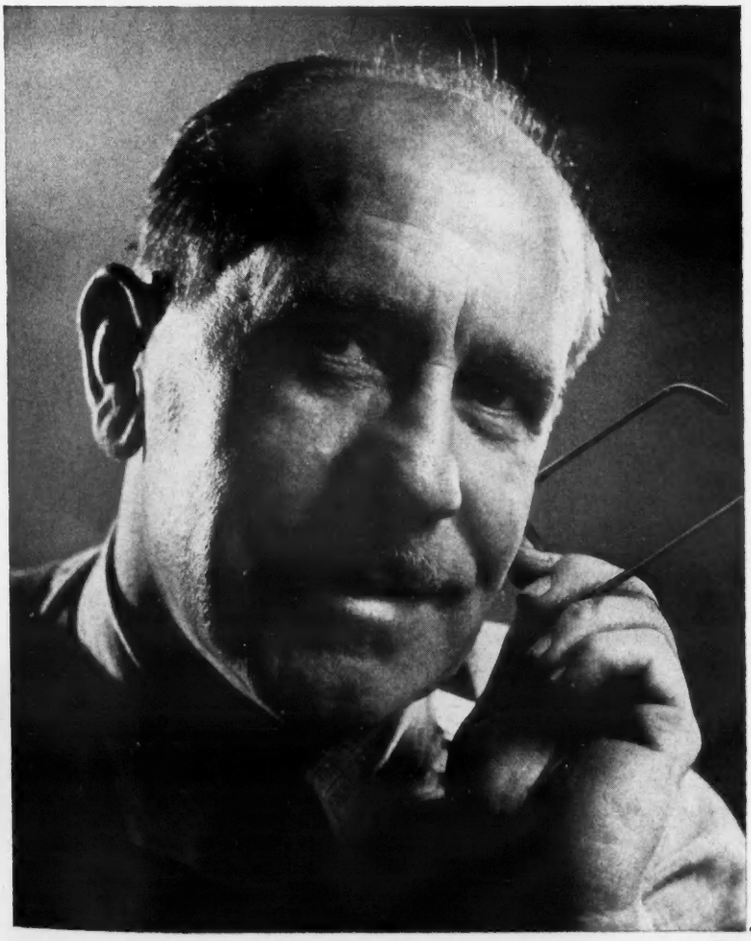

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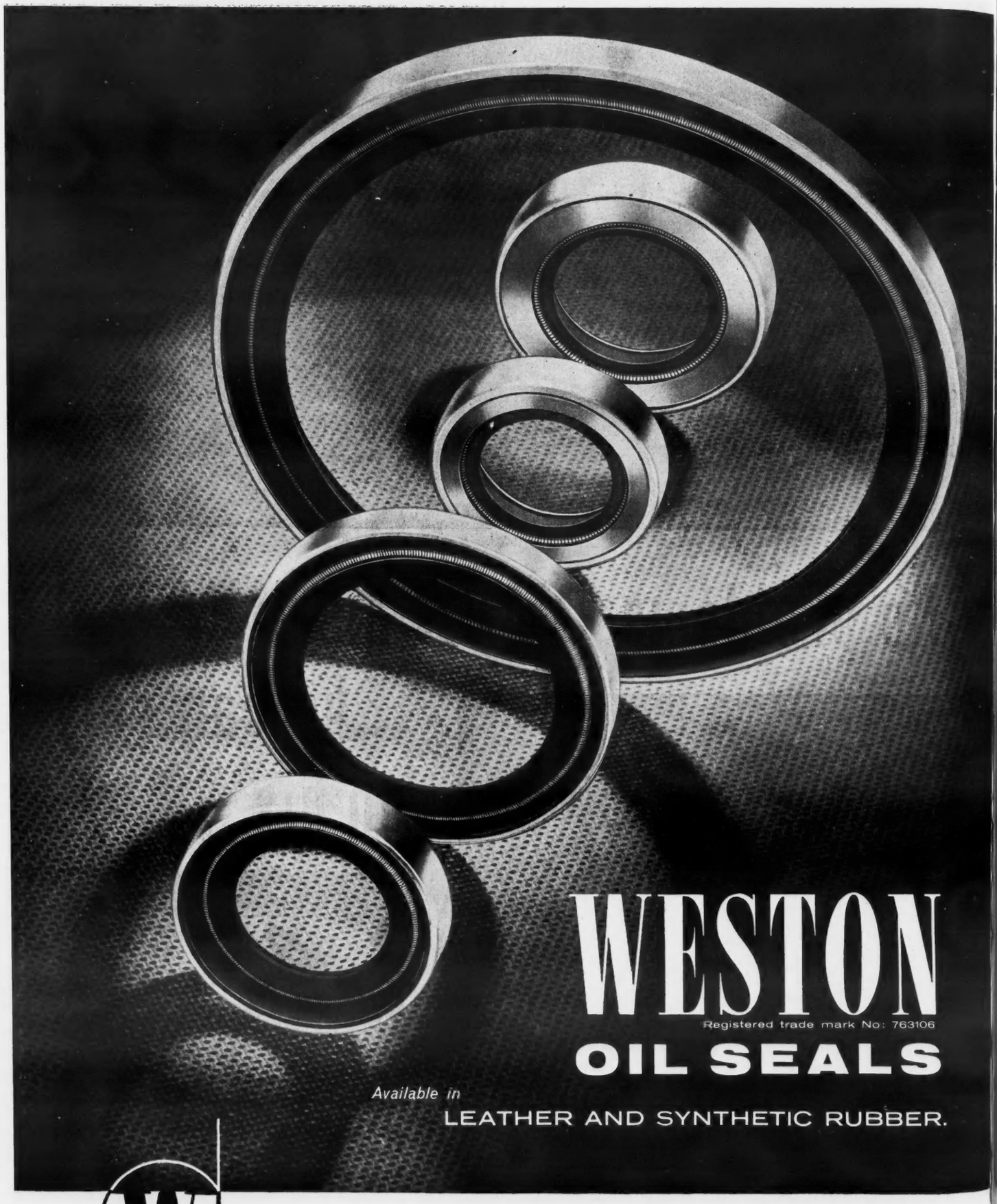

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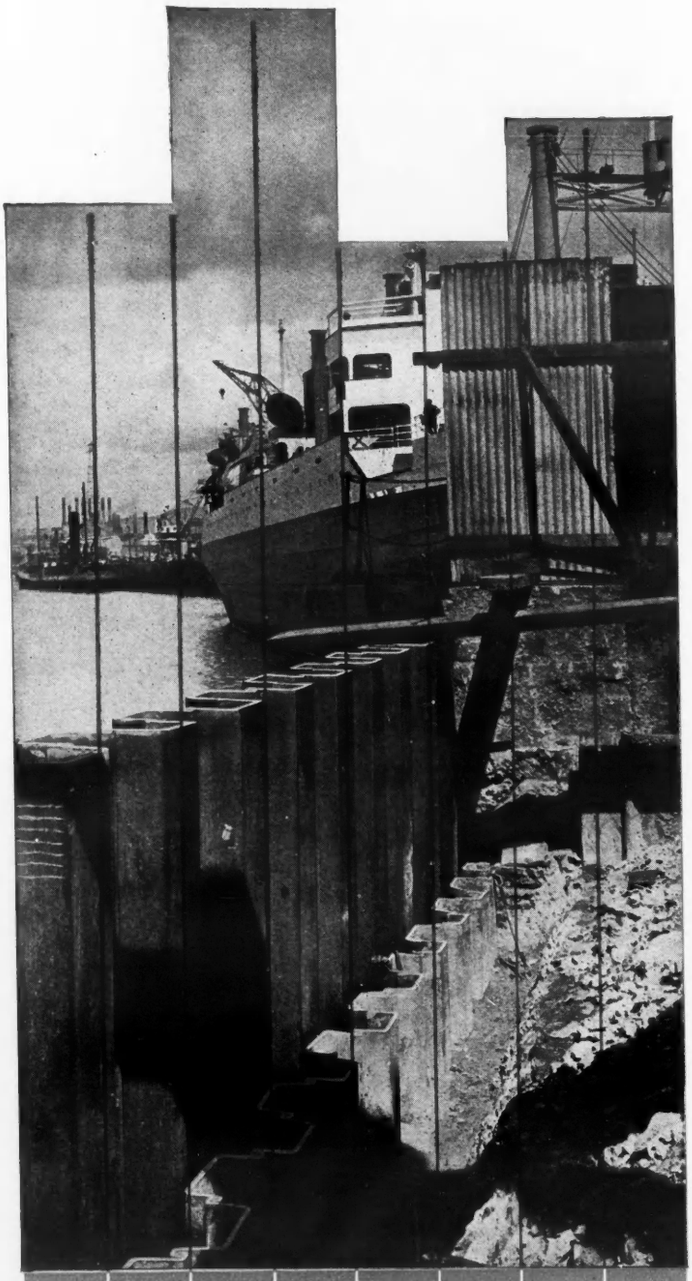

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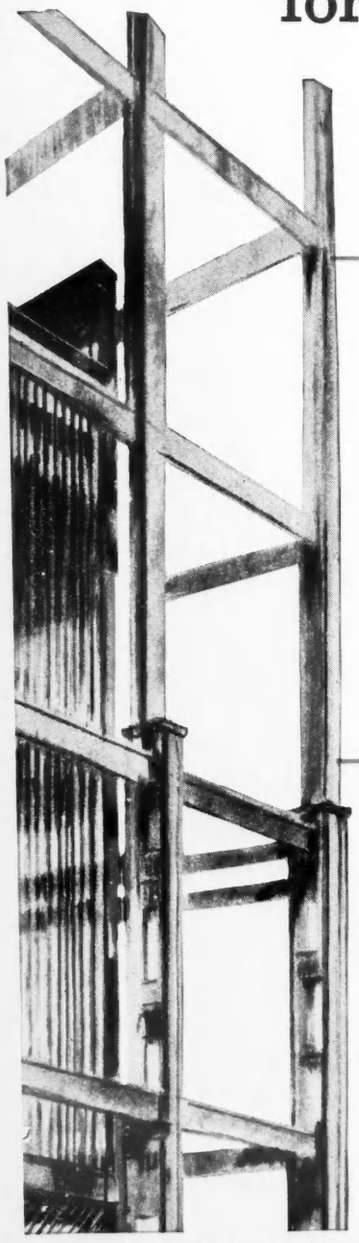
The International Combustion Organisation secures the contract for the LARGEST STEAM GENERATING UNITS for the Southern Hemisphere



International Combustion were responsible for the installation of the first 100 MW boiler units in the Southern Hemisphere—two units at TALLAWARRA, Australia.

◀ 100MW

Now at VALES POINT, Australia, two IC boilers of 200 MW capacity are to be installed :—

Continuous maximum rating : 1,350,000 lb/hr
Steam Pressure : 2,450 lb/sq. in.
Steam Temperature : 1,055°F
Reheat Temperature : 1,005°F

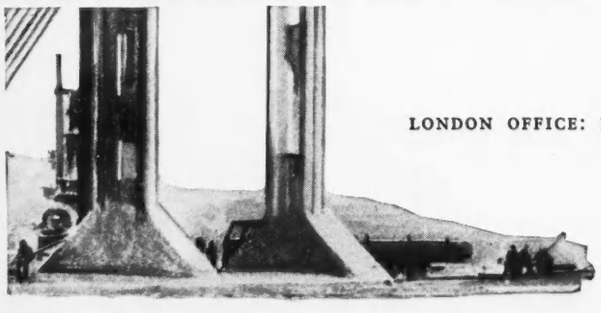
◀ 200MW

These will be the first high capacity controlled and assisted circulation boiler units in Australia and the first units in the country to employ a reheat cycle.

In England, International Combustion Limited are building five 200 MW units and one 550 MW unit for the Central Electricity Generating Board.

◀ 550MW

These projects indicate the confidence placed in IC equipment installed throughout the world, meeting the requirements both of large central electricity generation and the specialised applications of industry.



INTERNATIONAL IC COMBUSTION LIMITED

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MEMBER OF ATOMIC POWER CONSTRUCTIONS LIMITED—ONE OF THE BRITISH NUCLEAR ENERGY GROUPS

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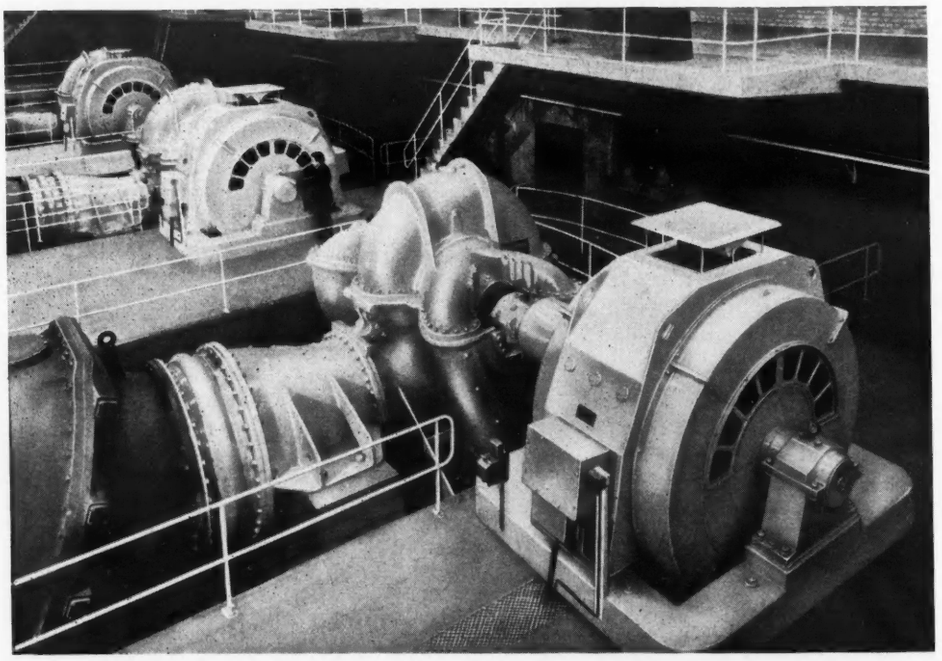
L

Mather & Platt

PUMPS & MOTORS . . .



. . . *for* POWER STATIONS

Illustrated are three of five sets of Mather & Platt Induction Motors and Lonovane pumps, installed in a C.E.G.B. Generating Station.

The Induction motors, each rated at 2,350 b.h.p. at 375/373 r.p.m., working from 3 phase, 50 cycles, 6,600 volts supply drive the Lonovane pumps, which have a 72in. suction and delivery.
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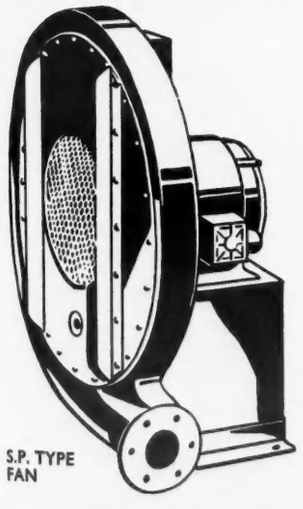

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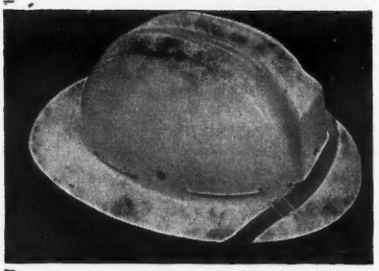

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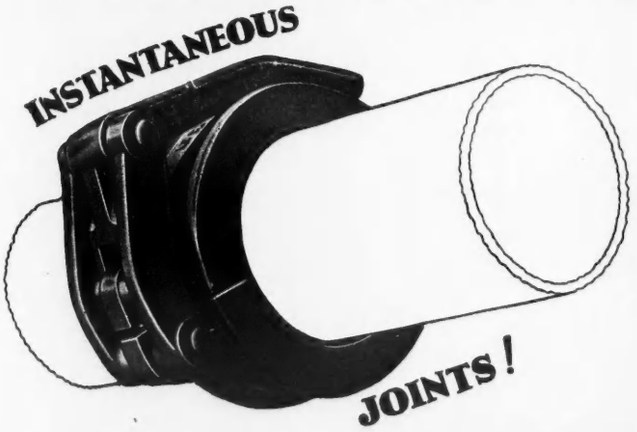

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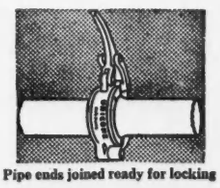
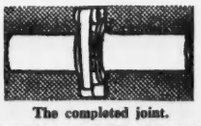


Pipe ends joined ready for locking



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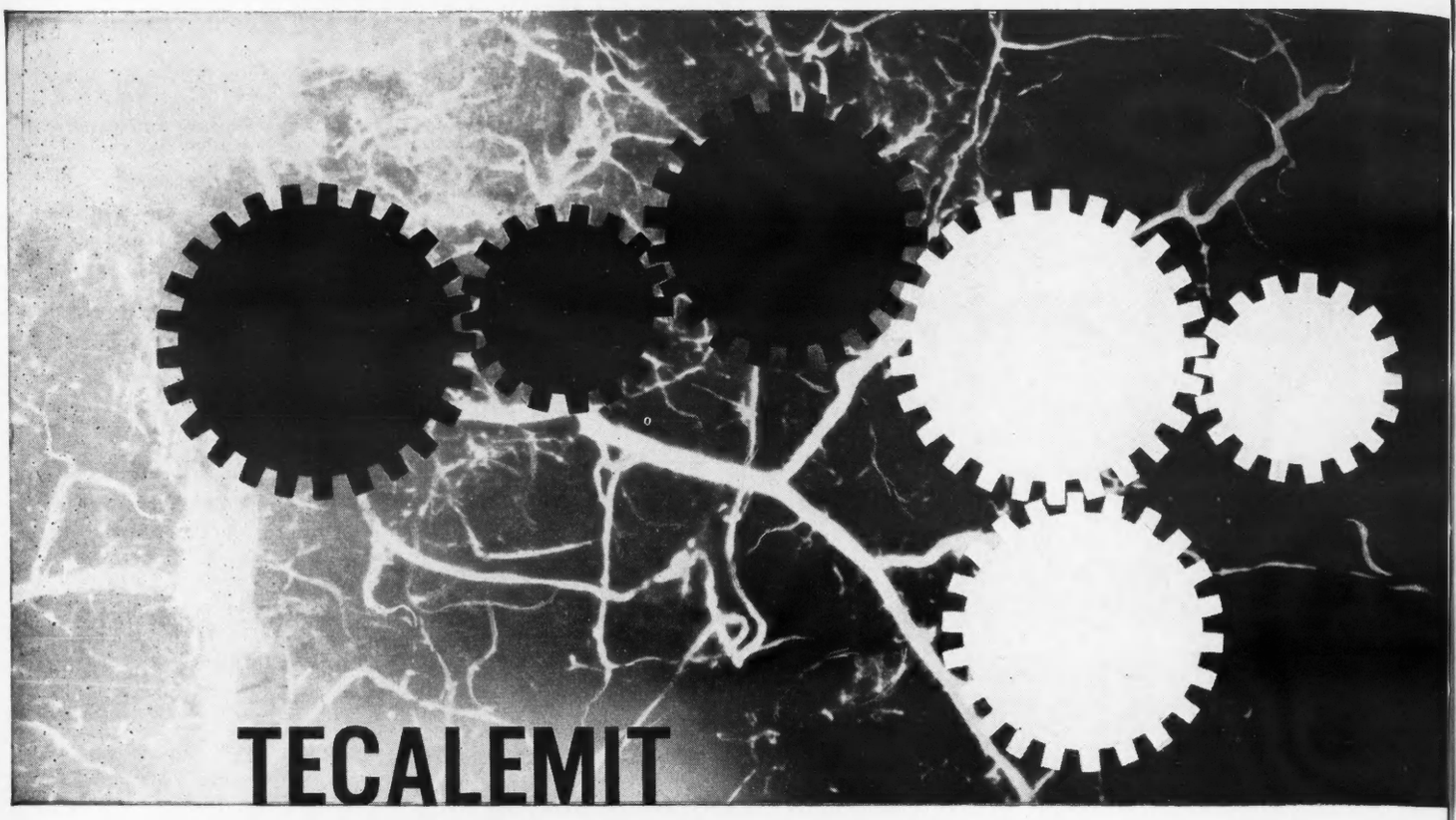

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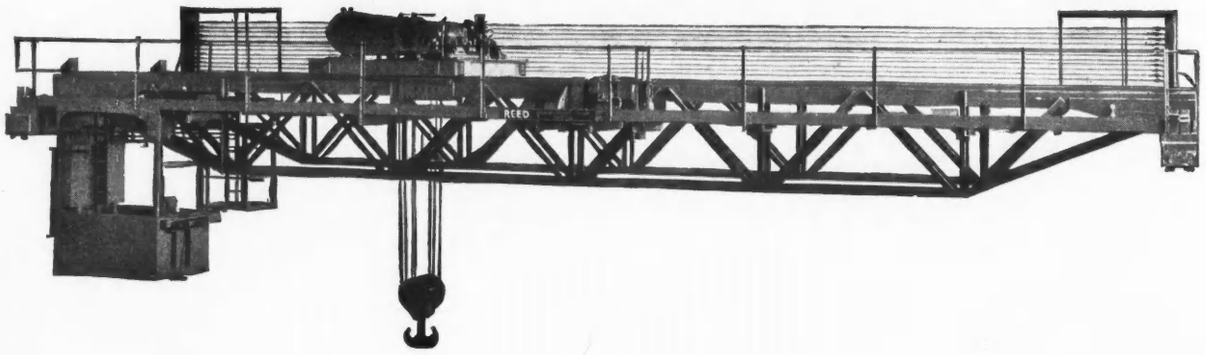

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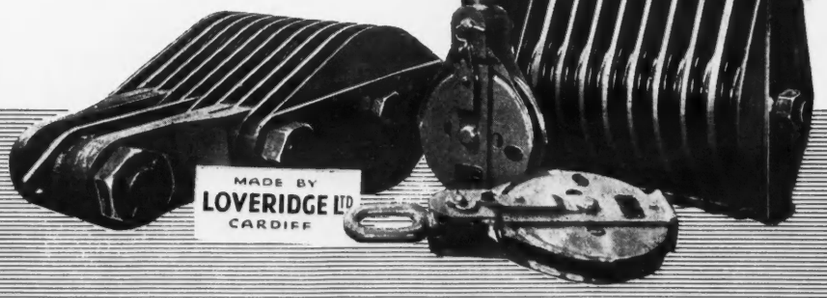

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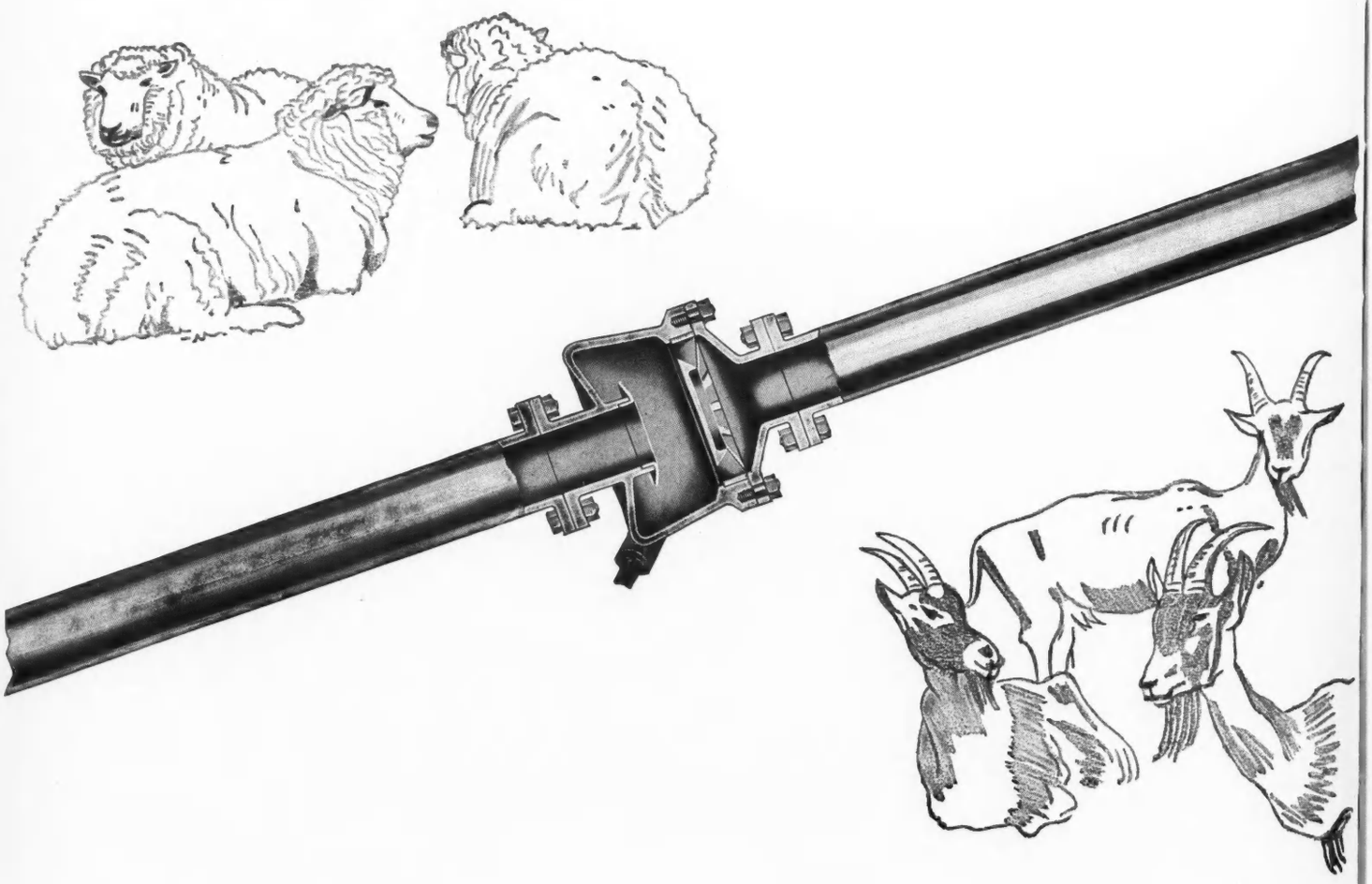

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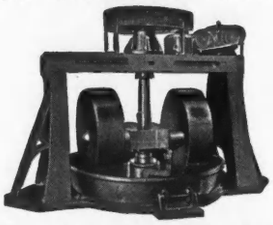

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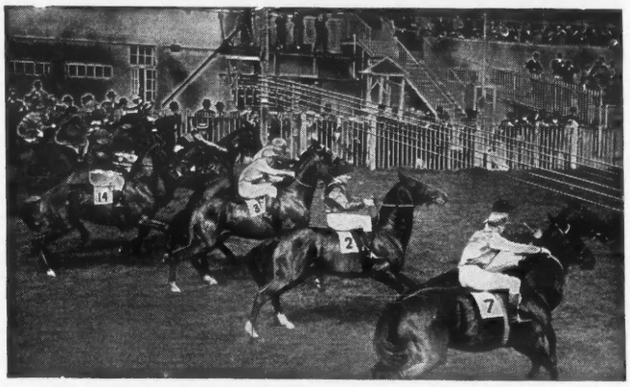
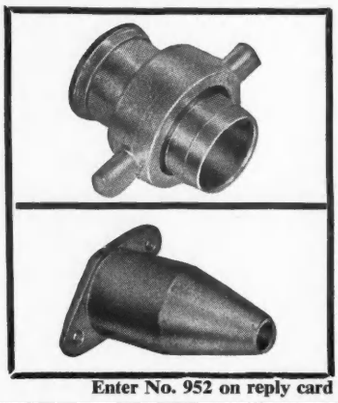


The choice is often difficult



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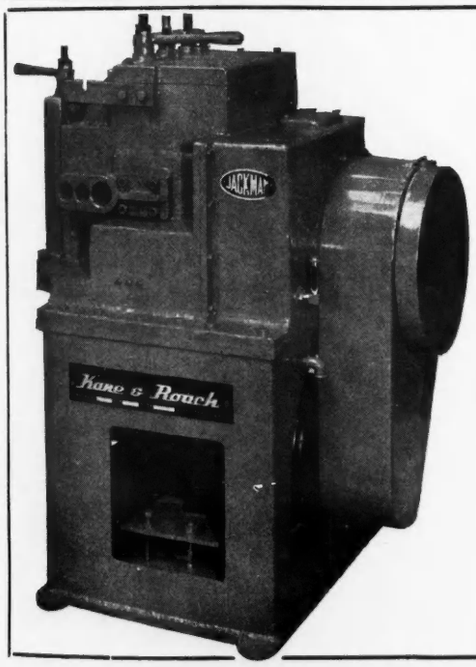

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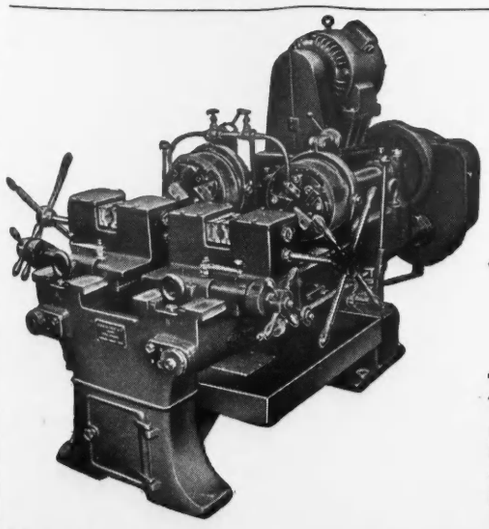

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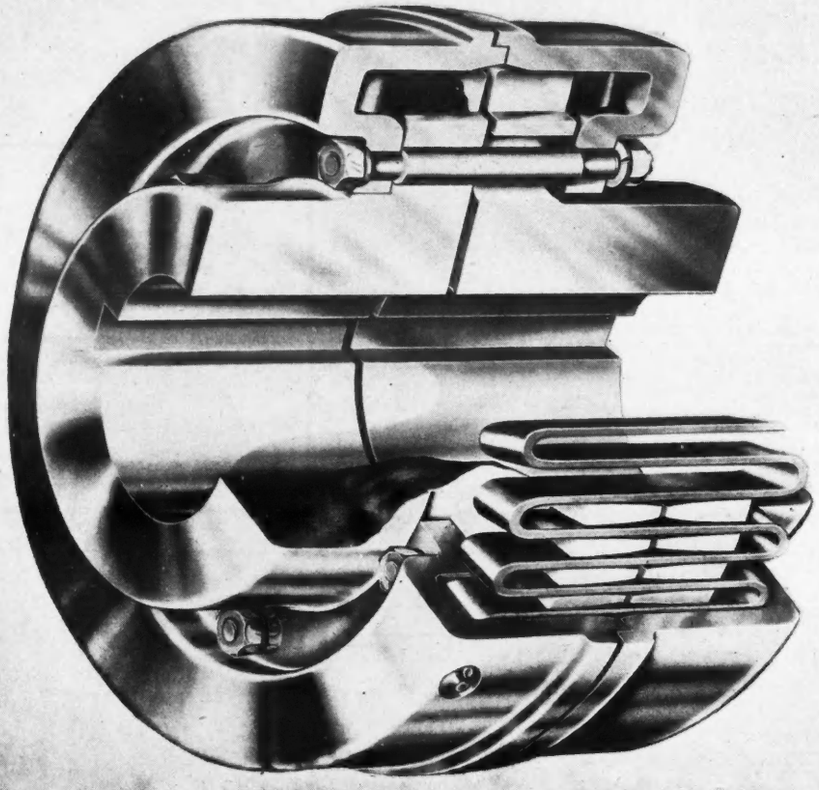

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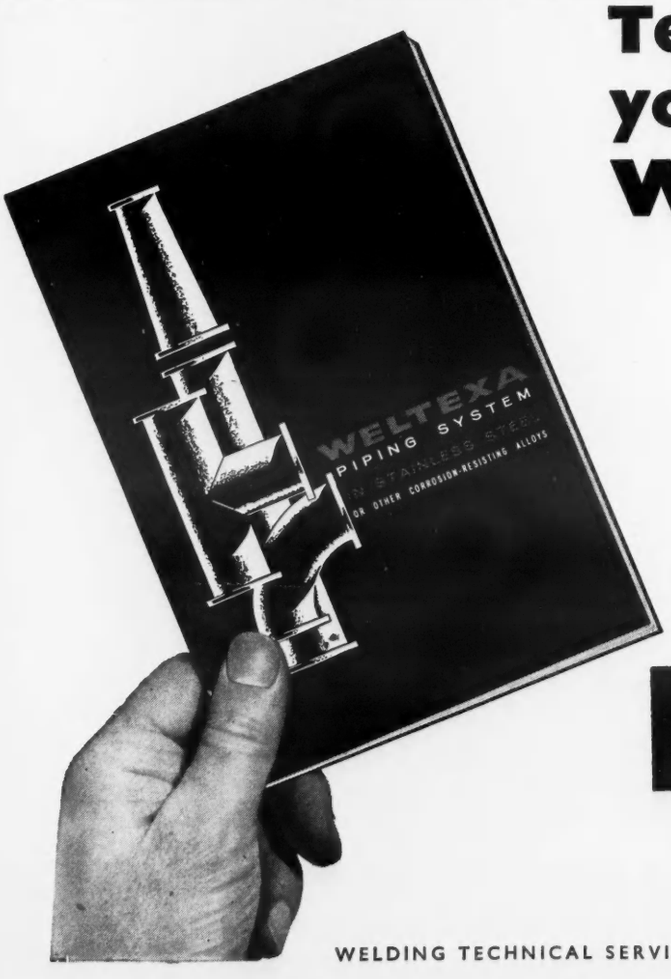

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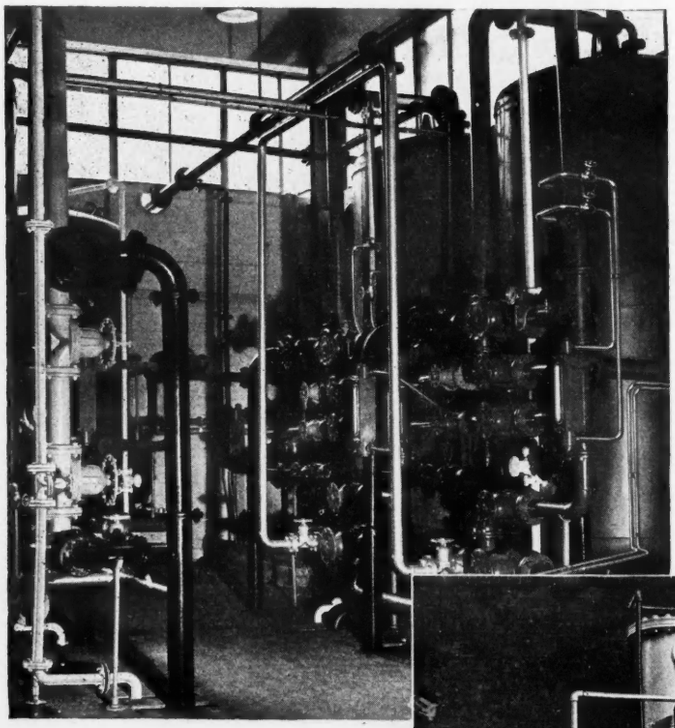

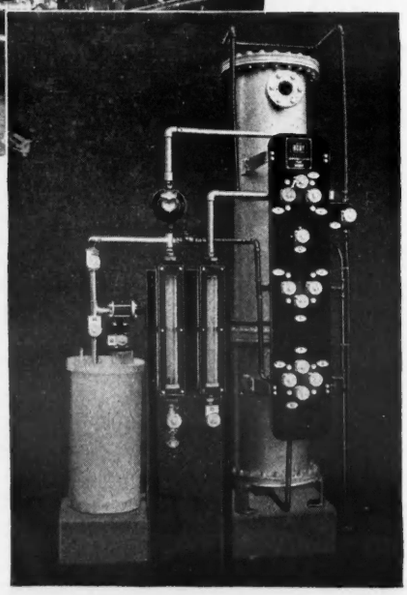

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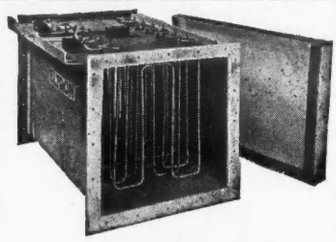

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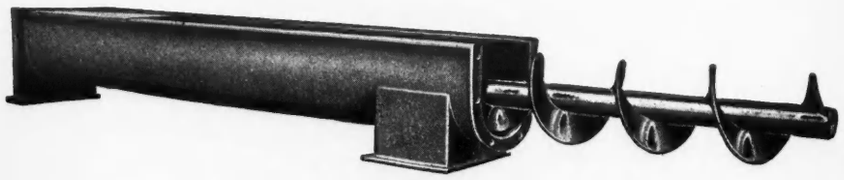

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"Goin' like a bird with them new L & C Piston Rings, ain't she, Chief ?"

"Eh ?"

"Engines . . . . like a bird . . . . lovely!"

"Och, ye mean that wee lassie in Liverpool ?"

"No, I'm not talkin' about 'er!"

"Which one are ye talkin' aboot then? Ye'd do far better to keep your mind on the engines. Don't ye think they're goin' like a birrrd since we fitted those L & C piston rings ?"

LOCKWOOD & CARLISLE LTD

Manufacturers of the well known "Patent Double Action Piston Rings" for steam engines

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Body panels, wings, cabs, silencers, petrol tanks, etc,. etc.

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Main control cabinets, instrument panels and boxes, receiver chassis, etc.

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Wherever hot-wet metal surfaces are found —with temperatures above 170°F—'Apexior No. 1' prevents corrosion.

Easily applied by brush or spray this outstanding coating provides effective *low cost* protection for expensive boiler plant . . . means less costly maintenance.

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Photograph by courtesy of William Gray & Co. Ltd.

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High Grade Soft Grey Iron & Non Ferrous Castings

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TYSELEY FOUNDRY LTD.

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ACOCKS GREEN 1283
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For the General Engineering, Machine Tool & Electrical Trades

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Special Offer! Price Reduction

EDWIN DANKS OF OLDBURY

ANNOUNCE A REDUCTION OF

7½%

FROM THE STANDARD LIST PRICES OF

Oldbury Chain Grate Stokers

ordered in the twelve months commencing 1st November 1959.
Hire purchase terms are available from that date.

This offer is made in recognition of the national importance of maintaining a healthy coal industry and in support of the National Coal Board Campaign.

Proved by 17 years' successful operation, the Oldbury Stoker endorses the claim of the National Coal Board that coal, the home produced fuel, is competitive in price and performance with other fuels.

The Oldbury Stoker, the first successful chain grate stoker for shell boilers, was developed by Edwin Danks of Oldbury in 1942, with the prime object of burning efficiently low grade slacks, owing to the shortage of graded fuels. To-day more than 6,000 Oldbury Stokers are in the service of industry, burning all sorts of solid fuel—

ECONOMICALLY by reducing fuel and labour costs.
SMOKELESSLY in compliance with the Clean Air Act.

Manufacturers who appreciate the manifold advantages of burning Britain's native coal are invited to send for details of our Special Offer and Publication 1618 — THE OLDBURY STOKER.

EDWIN DANKS & COMPANY (OLDBURY) LIMITED
OLDBURY, BIRMINGHAM. Telephone: Brierley Hill 77311
LONDON · BIRMINGHAM · CARDIFF · GLASGOW · LEEDS · MANCHESTER · NEWCASTLE-ON-TYNE

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CLASSIFIED ADVERTISEMENTS

PUBLIC APPOINTMENTS · SITUATIONS VACANT · TENDERS · EDUCATIONAL · BUSINESSES and PREMISES · BUSINESS OPPORTUNITIES PATENTS · MISCELLANEOUS · AGENCIES · DIRECTORS · PARTNERSHIPS

Lineage Rate. 4/6 per line of approximately 6 words. Minimum 18/-. **Inch Rate.** 54/- per single column inch and pro rata. 12 lines to 1 inch.

There are reduced rates (i.e., not on a pro rata basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £29 10s. ½-page £54. Full page £100.

FOR SALE · MACHINERY, etc., WANTED · AUCTION SALES · SITUATIONS WANTED · SUB-CONTRACTING · DESIGN SERVICES · FOR HIRE

Lineage Rate. 4/- per line of approximately 6 words. Minimum 16/-. **Inch Rate.** 48/- per single column inch and pro rata. 12 lines to 1 inch.

There are reduced rates (i.e., not on a pro rata basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £25 10s. ½-page £48. Full page £90.

Run-On and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/– which includes forwarding of replies.

Copy Dates. Tuesday for publication on Friday of the same week. If proofs are wanted, copy is required on Thursday for publication on Friday of the following week.

Advertisements for publication should be addressed to:—**Classified Advertisement Dept., "THE ENGINEER," 28 Essex Street, Strand, London, W.C.2**

Urgent advertisements may be telephoned to CENtral 6565.

PUBLIC APPOINTMENTS

ROYAL MILITARY COLLEGE OF SCIENCE

SHRIVENHAM

ASSOCIATE PROFESSORSHIPS

Three pensionable posts for men of high standing in their subjects as follows :

(a) in the Department of MATHEMATICS and PHYSICS with special interests in Ballistics ;

(b) in the Department of CIVIL and MECHANICAL ENGINEERING with special interests in Applied Mechanics, including Fluid Mechanics ;

(c) in the Department of CIVIL and MECHANICAL ENGINEERING with special interests in Applied Thermodynamics.

The successful candidates will be expected to undertake and lead research in their own fields and to teach at degree and post-graduate level. Salary £2300 to £2600 (under review). Starting pay may be above minimum. Existing superannuation rights preserved where possible. Secondment from, or transfer to, Scientific Civil Service possible. The College is residential ; rented houses available for married men, and quarters for single men. Write Civil Service Commission, 17 North Audley Street, London, W.1, for further particulars and application form quoting S/5156/60. Closing date 5th September, 1960. E5372

UNIVERSITY OF TASMANIA

LECTURESHIP OR SENIOR LECTURESHIP IN FLUID DYNAMICS

The University invites applications for the above-mentioned position.

The salary grades for Lecturers are Grade II £A1450 by £A60 to £A1630, and Grade I £A1630 by £A60 to £A2050, and for Senior Lecturers, £A2150 by £A60 to £A2510. It is expected that by the time the appointment is made, these scales will be Lecturer Grade II £A1610 by £A70 to £A1860, Lecturer Grade I £A1860 by £A70 to £A2350 and Senior Lecturers £A2450 by £A70 to £A2870. Appointment will be offered within one of the grades according to qualifications and experience.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1.

Applications close, in Australia and London, on 7th September, 1960. E5432

EAST SURREY WATER COMPANY

ENGINEERING ASSISTANT

The Company requires the services of a qualified CIVIL ENGINEERING ASSISTANT on the permanent staff to assist initially with a £750,000 capital works programme. The Company at present supplies an area of 280 square miles with 15 m.g.d.

Housing accommodation will be provided, if required, and removal expenses paid.

Starting salary will be between £1000 and £1250 per annum, according to experience, with pension rights.

Applications, giving details of age, education, qualifications and experience, should be received by the undersigned by the 1st August, 1960.

G. M. SWALES,
B.Eng., A.M.I.C.E., M.I.W.E.,
Chief Engineer.

London Road,
Redhill, Surrey. E5360

NATIONAL COAL BOARD

NORTH EASTERN DIVISION

CIVIL ENGINEERING ASSISTANT

CIVIL ENGINEERING ASSISTANT required at No. 4 Area Headquarters, Grimethorpe, Nr. Barnsley.

Candidates should have professional experience in Civil Engineering. Experience in projects through the various stages from inception to completion and of contract documents and administration of contracts is desirable. Duties include giving advice on the civil/structural engineering aspects of surface installation and assistant in planning and reconstruction.

Salary : £750 to £1150.

Apply, giving full details to Area Staff Manager at above address by 30th July. E5441

PUBLIC APPOINTMENTS

EAST ANGLICAN REGIONAL HOSPITAL BOARD

REGIONAL ENGINEER'S DEPARTMENT

APPOINTMENTS

(1) ENGINEERS, GENERAL GRADE (MECHANICAL)

(a) Corporate members Inst.Mech.E.: Salary £1160 to £1600.

(b) Associate members Inst. H. & V.E.: Salary £910 to £1400.

(c) Graduate members Inst.Mech.E.: Salary £910 to £1205.

(2) ENGINEERS, GENERAL GRADE (ELECTRICAL)

Graduate members Inst. E.E.: Salary £910 to £1205.

Candidates appointed will be engaged on design of central heating and hot water systems, air conditioning equipment, &c., including design of steam boiler plant, laundry installations OR electric lighting and power installations, radio and telephone installations and electronics in relation to hospital engineering projects. Experience in estimating and in the preparation of specifications desirable.

Candidates appointed under (1) (a) or (b) will be responsible for a small design team for all aspects of mechanical engineering services in large hospital building projects.

(3) ENGINEERING DRAUGHTSMEN (MECHANICAL AND ELECTRICAL)

(i) Salary £1030 to £1250.

(ii) Salary £870 to £1010.

(iii) Salary £550 to £850.

Candidates for (i) and (ii) should have H.N.C. or O.N.C. and be experienced in the design of engineering works and the preparation of tender drawings and specifications under supervision.

Candidates for (iii) should have had three years practical and theoretical training including site or workshop experience with suitable technical experience in engineering drawing.

Applications, stating age, qualifications, experience and details of present position, with names of three referees to Secretary of Board, 117 Chesterton Road, Cambridge, by 31st August, 1960. E5423

MINISTRY OF AVIATION

KIDBROOKE, LONDON

TECHNICIAN

Ministry of Aviation, Kidbrooke, London, require TECHNICIAN to assist in the preparation of packaging specifications for a wide range of Service stores. Qualifications : Recognised engineering apprenticeship. O.N.C., appropriate City and Guilds Final certificate or equivalent practical experience in packaging, and sound knowledge of packaging to Service requirements, preferably as applied to spares for road making plant or vehicles generally. Salary £720 (age 26) to £900. Application forms from the Manager (P.E. 2208), Ministry of Labour, P. & E. Register, Atlantic House, Farringdon Street, London, E.C.4. E5426

CENTRAL ELECTRICITY GENERATING BOARD

SITE SAFETY OFFICER

A SITE SAFETY OFFICER is required for the Rugeley (Staffs.) Power Station Site of the Central Electricity Generating Board. A thorough knowledge of the Factory Acts and Building Regulations is essential and experience of actual site construction is desirable. Salary in the neighbourhood of £1000 per annum commensurate with experience.

Applications in writing should be sent to :

The Resident Engineer,
Mott, Hay and Anderson,
Rugeley Power Station,
Rugeley,
Staffs,

not later than 3rd August, 1960. E5433

PUBLIC APPOINTMENTS

GOVERNMENT OF TANGANYIKA

CONTROLLER

CONTROLLER of Apprentices and Trade Testing (male, aged 30 to 40) required :

(i) To assist in the encouragement of apprenticeship schemes, the drawing-up and registration of suitable apprenticeship agreements, the placing of apprentices with suitable firms and supervision of their training.

(ii) To initiate schemes of trade testing of artisans of all nationalities in a variety of trades connected with the major industries in the Territory.

(iii) To advise on the framing of any legislation relating to apprenticeship or trade testing schemes or to industrial training in general.

(iv) In carrying out these duties the Controller will be required to collaborate, when necessary, with the other appropriate authorities in Tanganyika and in the other East African Territories.

Candidates must possess wide practical knowledge of manual skills, craft processes, apprenticeship schemes and testing techniques under advanced industrial conditions. Industrial experience should be supported by sound theoretical knowledge relating to building or engineering industry and candidates must be able to mix well with their colleagues in Technical Education and representatives of employers and workers. Candidates with degree in Engineering or Science or equivalent, i.e. A.M.I.C.E., A.M.I.E.E. or A.M.I.Mech.E. preferable. Post on contract/resettlement grant terms. Salary scale £1677 to £1863 inclusive. Quarters at low rental. Free passages and medical attendance. Education allowance (in respect of children educated in secondary schools outside Tanganyika). Tour of service 30-36 months. Low income tax. Generous home leave. Further particulars and application forms from the Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD. 132/8/06/D4. Candidates should state their full names on applying. E5449

SOUTHEND WATERWORKS COMPANY

APPOINTMENT OF ENGINEERING ASSISTANT

Applications are invited from qualified Engineers for the post of Engineering Assistant (New Works) within the salary range £1200 to £1375. Commencing salary depending on experience.

Candidates should be Associate Members of the Institution of Water Engineers, and have had some experience in the design of water retaining structures, pump houses, and in the laying of large diameter mains.

The appointment, which will be terminable by one month's notice on either side, will be subject to a satisfactory medical report, after which the applicant will be required to join the Company's superannuation scheme.

Applications endorsed "Engineering Assistant," stating age, qualifications and experience, and giving the names of two persons to whom reference may be made, should be sent to The General Manager, 13, Cambridge Road, Southend-on-Sea, not later than the 13th August, 1960. E5417

MINISTRY OF AVIATION

WOOLWICH, LONDON

TECHNICIAN

Ministry of Aviation, Woolwich, London, require TECHNICIAN to assist in the preparation specifications, inspection instructions and compilation of technical details for the provision and inspection of Land Service Pyrotechnics and associated packages. Qualifications : Recognised engineering apprenticeship. O.N.C., appropriate City and Guilds Final Certificate or equivalent knowledge of production of pyrotechnics or kindred stores and general inspection requirements advantage. Salary £720 (age 26) to £900. Application forms from Manager (P.E.2204), Ministry of Labour, P. & E. Register, Atlantic House, Farringdon Street, London, E.C.4. E5437

PUBLIC APPOINTMENTS

WEST PARK HOSPITAL

EPSOM, SURREY

ENGINEER

ENGINEER required. Salary : £940 by £25 (1) by £30 (4) to £1085 (plus London Weighting). Conditions of service as laid down in National Health Service Regulations. Appointment subject to satisfactory medical examination. The hospital accommodates 2000 patients suffering from mental illness. Steam is to be provided from a Central Boiler House elsewhere. An unfurnished house is available at a reasonable rental.

Applications will only be considered from candidates who satisfy the following conditions, and who possess one of the qualifications listed or an approved equivalent qualification.

Candidates must have had a thorough practical engineering training with wide experience in a supervisory position of such types of mechanical and electrical engineering services as are found in institutions and as are appropriate to the responsibilities of the post.

Qualifications :

Ministry of Transport and Civil Aviation (ex Board of Trade) First Class Certificate of Competency in Marine Engineering.

Ministry of Transport and Civil Aviation Certificate of Service as First Class Engineer.

City and Guilds full Technological Certificate in Plant Engineering (First Class).

The successful candidate will be directly in charge of the engineering services of the hospital ; he will supervise the carrying out of works of engineering maintenance ; and may also be responsible for the design or execution of minor new works either by direct labour or contract.

Applications with full particulars, together with the names and addresses of three referees, should be sent to the Group Secretary by 30th July, 1960. E5436

REPUBLIC OF THE SUDAN

RESIDENT ENGINEER

Applications are invited from suitably qualified engineers to fill a vacancy as RESIDENT ENGINEER, Sennar Burri Project, in the Central Electricity and Water Administration, Sudan. The above project comprises a 10MW extension to an existing steam station in Khartoum. 180 miles of single circuit, 110KV overhead line with 4 primary substations and a 15MV hydro-electric station at Sennar.

Applicants should have extensive experience in installation and commissioning of heavy electrical-mechanical plant and will be expected to supervise contractors in all aspects of the job and particularly the erection and testing of the steam and hydraulic-turbo generators and their associated equipment.

The appointment will be on contract for a period of three years at a salary of £S.2750 (£S.1=£1. 0s. 6d.) In addition to the salary a variable cost-of-living allowance, at present £S.187 per annum is payable. There is no income tax in the Sudan at present.

Furnished accommodation is available at a nominal rent, approximately £S.200 per annum. Free medical attention is provided for the official and family. Annual leave accrues at the rate of seven days per month on full pay and is granted after an initial period of eighteen months has been served with the Administration.

Applications should be made in writing, giving particulars of qualifications, experience and age, and enclosing copies of two recent testimonials, to the Appointments Section, Sudan Embassy, 3 Cleveland Row, St. James's, London, S.W.1 (quoting reference 4/3200).

Closing date 15th August, 1960. E5443

RIVER DOVE WATER BOARD

ASSISTANT CIVIL ENGINEERS

Qualified engineers required urgently to assist in completing the first stage of a £5 million project, including a rolled fill dam and hydro-generation plant, and also for the design and construction of the second stage, including pumping plant, water tower and a 10 mg reservoir. Applicants should preferably have some experience in designing in reinforced concrete and have waterworks experience.

Salaries offered within the A.P.T. Scale IV : £1065 to £1220. General conditions of Service will apply, the posts are superannuable and subject to medical examination.

Applications should be sent to Engineer and Chief Executive, River Dove Water Board, Bowling Green Street, Leicester, by Friday, 29th July, 1960. E5409

Classified Advts. continued on page 104

PUBLIC APPOINTMENTS

WALES GAS BOARD

APPOINTMENT OF ENGINEERING ASSISTANT (ELECTRICAL)

Applications are invited for the position of ENGINEERING ASSISTANT (ELECTRICAL) in the Mechanical Engineers Department, Technical Headquarters, Cardiff.

Applicants should have received a good technical education to a minimum standard of Higher National Certificate in Electrical Engineering and be experienced in the preparation of specifications and wiring diagrams for the installation of all types of motors, generators, switchgear and electrical instruments. Experience in the installation of the above associated with gas producing and gas transmission machinery would be an advantage.

Experience in LV, MV, and HV supplies would be an advantage and the applicant must be familiar with all the latest Codes of Practice, I.E.E. Regulations and the Electricity Regulations of the Factories Act.

The salary offered is within A.P.T. Grade 12 of the National Salary Scales for Gas Staff (£1006 to £1131 p.a.). The position is pensionable.

The successful applicant will be required to pass a medical examination.

Applications giving the names of two referees must be received by the undersigned not later than Wednesday, 10th August, 1960.

C. B. MAWER,
Secretary.

Wales Gas Board,
2, Windsor Place,
Cardiff. E5463

PUBLIC APPOINTMENTS

ST. EDWARD'S (PSYCHIATRIC) HOSPITAL

CHEDDLETON, NR. LEEK, STAFFS
(1350 BEDS)

SUPERINTENDENT ENGINEER

SUPERINTENDENT ENGINEER required; practical experience in a hospital is desirable. Salary scale £930 rising by 5 annual increments to £1090 per annum. The person appointed will be responsible for the satisfactory operation and maintenance of the hospital's engineering services, including both mechanical and electrical; he will also be responsible for the supervision of the maintenance of the buildings. Will be required to live in the hospital house provided, at a rental. Unless eligible for promotion through previous Health Service experience, candidates should hold one of the following qualifications or an approved equivalent :— M.T.C.A. First Class Certificate of Competency in Marine Engineering; M.T.C.A. Certificate of Service as First Class Engineer; City and Guilds full Technological Certificate in Plant Engineering (First Class); Higher National Certificate in Mechanical or Electrical Engineering.

Applications by 30 July, 1960 stating age and with full details of qualifications and experience, together with names of three persons to whom reference may be made, to The Group Secretary from whom further details, if required, may be obtained. E5452

SOUTH AUSTRALIAN GOVERNMENT

Applications are invited for appointments in the following professions in the Government Service of South Australia:—

	Salary ranges
Engineers, Civil, Mechanical and Electrical..	£A1170 — £A1920
Surveyors and Assistant Surveyors	£A1340 — £A1525
Draftsmen, Structural	£A1340 — £A1525

Commencing salaries within these ranges according to qualifications and experience.

First class passages provided for selected applicants and families.

Good leave conditions (Recreation, Sick and Long Service). Superannuation Fund available. Houses on a rental basis provided.

Full information from:—
Agent General for South Australia,
50 Strand, London, W.C.2. WHItehall 7471

E5454

COLLEGE OF ADVANCED TECHNOLOGY BIRMINGHAM

Department of Production Engineering

Applications are invited for the following posts:

READER (RESEARCH ENGINEER)

Candidates must be qualified engineers with experience in research and development in production engineering technology to develop post-graduate courses and research projects and to be responsible for an important section of undergraduate work.

PRINCIPAL LECTURER in MACHINE TOOLS AND DESIGN
PRINCIPAL LECTURER in METROLOGY and QUALITY CONTROL

Candidates should have good academic and professional qualifications and have had industrial experience with technical responsibility in the relevant subjects; ability to develop and co-ordinate the teaching and laboratory work; organise special advanced courses and maintain liaison with industry.

LECTURER in PRODUCTION ENGINEERING

Candidates should be well qualified technically and professionally and have held a responsible position regarding some aspects of production engineering technology in industry. Experience in development work and experimentation is desirable with ability to develop subjects such as Machine Tools, Metrology and Tool Engineering and other production engineering technology to a high level.

Salary Scales:

READER	(Men)	£1,800 – £2,100
PRINCIPAL LECTURER	(Men)	£1,750 – £1,900
LECTURER	(Men)	£1,370 – £1,550

Further particulars and forms of application from the Bursar, College of Advanced Technology, Gosta Green, Birmingham, 4. Applications to be received within 14 days of this advertisement. Please quote J.

K. R. PILLING, Clerk to the Governors. E5460

TENDERS

MINISTRY OF TRANSPORT

TRAILER GRITTERS

The Minister of Transport invites TENDERS for the supply of :—
SIXTY BULK TRAILER GRITTERS
SEVENTY MANUALLY FED TRAILER GRITTERS.

Copies of the specifications may be obtained from the Chief Mechanical Engineer, Ministry of Transport, Room 401, 21-37, Hereford Road, London, W.2.

Tenders should be sent in a sealed, registered envelope endorsed "Tender for trailer gritters", but not bearing any name or mark indicating the sender, and addressed to the Assistant Secretary, Ministry of Transport, 21-37, Hereford Road, London, W.2, to arrive not later than 4 p.m. on Thursday 11th August, 1960.

The Minister does not bind himself to accept the lowest or any Tender.

G. G. D. HILL,
E5451 An Assistant Secretary.

EDUCATIONAL

COLLEGE OF AERONAUTICS

ONE YEAR POST-GRADUATE COURSE IN AUTOMOBILE ENGINEERING

Applications are invited for a course which begins in October, 1960. Applicants should generally be university graduates in science or engineering, or holders of a diploma in technology, and should have had two years practical experience in industry.

The course will consist of lectures, laboratory demonstrations and student investigations conducted under supervision. The major subjects in the course will be thermodynamics and engine design, structural design and analysis, and vehicle stability and handling. In addition, students will attend lectures on general engineering subjects.

Students who successfully complete the course will be awarded the Diploma in Automobile Engineering (D.Au.E.).

Further information and forms of application may be obtained from The Warden, The College of Aeronautics, Cranfield, Bletchley, Bucks.

E5456 E

UNIVERSITY OF MANCHESTER

METROPOLITAN VICKERS POSTGRADUATE BURSARIES

Applications are invited from honours graduates in Engineering, Physics of Mathematics for a number of post-graduate bursaries of a value normally within the range of £350 to £700 per annum, although this maximum may be exceeded in certain cases. The bursaries are tenable for research and advanced study in the departments of Electrical and Mechanical Engineering in the Faculty of Science or of Technology. Applications, naming the department and Faculty in which the candidate proposes to work, should be sent not later than August 17th, 1960, to the Registrar, the University, Manchester, 13, from whom further particulars and forms of application may be obtained. E5459 E

A.M.I.MECH.E., B.SC., City and Guilds, &c. Guarantee Postal Courses for all Exams. and Technical Divisions from Elementary to Degree standard including Automation Techniques. Approximately 95 per cent. successes. 148-page, prospectus, free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES NOT ORIGINALS OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

A SMALL BUT SUBSTANTIAL FIRM of electro-mechanical engineers in the Hounslow area wishes to appoint a fully qualified Chartered Mechanical Engineer with 5 to 10 years' experience in the design and development of precision mechanisms An applicant of sufficient calibre will be considered for the post of CHIEF MECHANICAL ENGINEER. A salary of up to £2000 per annum is envisaged and the usual staff amenities apply. Working conditions are good.—Applications, which will be held in absolute confidence, should be addressed for the personal attention of the Technical Director, Box TE.475, c/o Hanway House, Clark's Place, E.C.2. E5440 A

AN ENGINEERING ASSISTANT is required by JACKSON BROS. (OF KNOTTINGLEY) LTD., to be responsible directly to the Chief Engineer and to be engaged on the design and production of glass bottle mould equipment.

The post calls for initiative and a good technical background, together with practical experience in machine-shop layout and modern methods of machine tool operation.

Applications are invited from young engineers with a suitable background who are prepared to undergo further training and to continue their studies with a view to qualifying for the post.

Please reply, in the first instance stating age, qualifications and experience, to :
THE PERSONNEL OFFICER, JACKSON BROS. (OF KNOTTINGLEY) LTD., HEADLAND GLASSWORKS, KNOTTINGLEY, YORKSHIRE. E5439 A

DESIGN DRAUGHTSMAN required to work on Marine Propulsion Gears. Vacancies at Westminster and also Chesham offices. Permanent, pensionable positions. Good salaries.—Apply in first instance in writing to Technical Manager, Modern Wheel Drive Ltd., Lindo Lodge, Chesham, Bucks. E5391 A

SITUATIONS VACANT

ASSISTANT CHIEF ENGINEER

Civil and Mechanical Engineer required to fill the above vacancy in a large oil storage installation at Thames Haven, Essex.

Applicants between the ages of 40-45 should have a degree in engineering, together with long-term practical experience including administration, planned maintenance and budgetary control.

Salary commensurate with age and experience. Contributory Pension Scheme.

Write, giving full details to :

The Managing Director,
London and Thames Haven Oil Wharves Ltd.,
Bucklersbury House,
83 Cannon Street,
London, E.C.4.

E5431 A

CHIEF MECHANICAL AND ELECTRICAL ENGINEER FOR INDIA. Applications are invited for the position of Chief Mechanical and Electrical Engineer for an established metalliferous Mine and allied factory under European management in India. Applicants must be corporate members of either Mechanical or Electrical Institutions. The Engineer selected will have overall responsibility for all Constructional work and the maintenance of all Electrical and Mechanical Plant and Equipment including Generating Plant. A good salary with house and generous allowances will be provided. There is an established Provident Fund and Pension Scheme, plus free medical attention, passages, &c.—Write in the first instance giving full details of experience &c. to Box JY/60, c/o 95, Bishopsgate, London, E.C.2. E5427 A

DESIGNER DRAUGHTSMAN for special purpose machine design, in connection with the Rubber and Plastics Industry. Applicant must be capable of working on own initiative. Experience of Mechanical and Hydraulic design and Mechanical Handling essential. Electrical knowledge an advantage.—Apply in writing to BOX No. E5438, "The Engineer." A

DRAUGHTSMAN
required for plant layout work with a medium-sized engineering company situated in the south-east Essex locality. Previous experience of factory buildings general services an asset. The ideal candidate would be aged between 24-30 years and possess O.N.C. or equivalent qualifications.

This is an interesting position in an expanding company which would appeal to a trained man requiring further experience.

Applications may be made in writing in the strictest confidence stating age, qualifications, experience and salary required to BOX No. E5435, "The Engineer." A

DRAUGHTSMAN (Proposal) for interesting work on complete Water-Tube Boiler installations. Applicants should have some previous experience of Water-Tube Boiler construction and layout. Salary according to experience. Contributory Pension Fund. Staff dining room.—State (in writing), age and experience.—Staff Manager, Foster Wheeler Limited, 3, Ixworth Place, London, S.W.3. E5425 A

DRAUGHTSMAN REQUIRED for Mechanical Engineering Company, Charlton District. Suitable candidate, preferably with H.N.C. or equivalent may be offered original development work.—BOX No. E2940, "The Engineer." A

DRAUGHTSMEN are required for interesting work on small electric motors of various conventional and novel designs in the drawing offices at our Islington and St. Albans factories. An apprenticeship or similar sound D.O. experience in mechanical engineering is required, electrical experience an advantage. Interviews in London or St. Albans.—Write in the first case to : Limit Engineering Group Ltd., 64 Essex Road, London, N.1. E2930 A

ENGINEERING INSURANCE. Applications are invited from Mechanical Engineers not over 35 years of age, who having served an apprenticeship with Crane and Lift Makers have a sound theoretical and practical knowledge of Cranes, Lifts, Lifting Machines and their maintenance, and are qualified to Higher National Certificate standard, for a vacancy as ENGINEER SURVEYOR based in the Stoke-on-Trent district. The position is permanent, pensionable, with salary scale of £800 rising to £1100 per annum, plus expenses and allowances. —Apply in own handwriting to BOX No. E5373, "The Engineer." A

HIGHLY QUALIFIED ENGINEER required by major cycle manufacturers in India. Must have had practical experience in latest production techniques and operation of automats. Excellent salary and home leave arrangements : free furnished house and other facilities. This is an unusual opportunity for an executive engineer capable of adapting himself to local conditions, who possesses drive and initiative as well as experience and who is seeking a permanent career in Asia. E5418 A

IMPORTERS REQUIRE REPRESENTATIVES already calling on Engineering Concerns to carry Welding Cutting Equipment and Machine Tools.—BOX No. E191, "The Engineer." A

INDUSTRIAL FURNACE CONSTRUCTION COMPANY engaged principally in Iron and Steel Industry on construction of all types of Furnaces require SITE ENGINEERS age 30 to 40 years, and JUNIOR SITE ENGINEERS age 23 to 30 years. Applicants should preferably be qualified engineers with Iron and Steelworks experience, but engineers with sound practical experience will be considered. They should be prepared to travel to sites in United Kingdom as required. These are permanent appointments with participation in Pension Scheme after probationary period. Salary commensurate with qualifications and experience, plus bonus.—Applications giving personal details, qualifications and experience to BOX No. E5362, "The Engineer." A

MECHANICALENGINEERINGDRAUGHTSMAN required, with experience of Design and Setting Out of Stone Aggregate Handling, Asphalt and Quarry Plants. Required to work in Greenwich area. Good commencing salary.—Apply, giving details of experience to the Chief Mechanical Engineer, Amalgamated Asphalte Companies Limited, Pear Tree Wharf, Horn Lane, Greenwich, S.E.10. E2946 A

SITUATIONS VACANT

MECHANICAL ENGINEER DESIGNER. Civil Engineering Contractors specialising in foundations require good practical man for design and development work. The Company builds the majority of its own plant at its St. Albans Depot where the successful candidate will be based. He will take charge of a small Drawing Office, supervise construction of his own designs and visit contract sites when necessary. Housing accommodation is available if required, and a contributory Pension Scheme is operated by the firm.—Apply in writing, giving details of experience and salary required to : Frankipile Limited, Hatfield Road, St. Albans, Herts.
E2945 A

OPPORTUNITY FOR STRUCTURAL DESIGNER

occurs at old-established works in pleasant country surroundings.

The man appointed will be required to work for a period as Assistant prior to assuming the position of Chief Designer and Estimator in an office which undertakes a variety of structural steelwork.

Applicants should have a sound experience in competitive design of various classes of steelwork including buildings.

A pension scheme is in operation. Three weeks annual holiday.

Write, stating age, experience and salary required to :

THE FAIRFIELD SHIPBUILDING AND ENGINEERING CO., LIMITED, CHEPSTOW, MON.

E5367 A

PERA requires the following additional staff :

MACHINE TOOLS

(1) Graduate or equivalent for research into machine tools and power presses. A knowledge of instrumentation and experience in hydraulics would be an advantage.

(2) Mechanical Engineer for development work in connection with machine tools and special purpose machinery. Experience in design is essential.

MACHINE DYNAMICS

Honours Graduate for work on vibration studies of machine structures, prototype machine tools, &c. Applicants should have some knowledge of instrumentation, and be interested in developing analogue computer techniques for using experimental results in design studies of advanced types of new machine tools.

AUTOMATION

Graduate or equivalent for research into problems of work handling, machine regulation and control, programming, &c., arising in the production engineering field. Experience in dealing with production engineering problems and an interest in the application of logical methods to the analysis of engineering systems would be valuable.

COLD EXTRUSION AND HIGH ENERGY FORMING OF METALS

(1) Honours Graduate for design studies and fundamental research. Applicants should have some knowledge of the theory of plasticity ; a knowledge of metallurgy would also be useful.

(2) Graduate or equivalent for applied research and development work. Toolroom or press tool design experience would be an advantage.

Each of the appointments provide excellent opportunities for men with capacity for original thought and initiative to make an effective contribution in these important and rapidly expanding fields of activity. Good commencing salary with annual increments on merit. Superannuation under F.S.S.U.—Applications to the Secretary, Production Engineering Research Association, Melton Mowbray, Leics. E5424 A

PROJECT AND ESTIMATE DRAUGHTSMAN required capable of handling complete Coal, Ash, and Foundry Mechanisation Schemes. Five-day week three weeks annual holiday, luncheon vouchers. BOX No. E5294, " The Engineer." A

SALES ENGINEER for London-based U.K. Agents leading German Engineering Group. Background of Chemical and Process Engineering. Experience of industrial centrifuging an advantage though not essential. Reasonable knowledge of German. Starting salary about £750. Applicants to give details of previous training and practical experience.—BOX No. E2952, " The Engineer." A

STRUCTURAL STEELWORK DETAILING, DRAUGHTSMAN required for expanding Company of Structural Engineers on the South Coast, Knowledge of design preferred but not essential. Very varied and interesting classes of work.—Write BOX No. E2941, " The Engineer." A

THE BURMAH OIL CO. (PIPE LINES) LTD., Britannic House, Finsbury Circus, E.C.2. have the following interesting vacancies for Engineers for service in India on a major crude oil pipeline project. Appointments will be on a bachelor basis.

Salaries free of Indian Taxation will be paid in Rupees (equivalent Sterling rates per annum are quoted below) and will be related to qualifications and experience. Messing and accommodation in India will be provided free.

SUPERINTENDING ENGINEERS (THREE)

Required to supervise inspection of Contractors' operations on Main Pipelaying Spreads and measurement of completed work and to take administrative charge of inspectors on the spread.

Minimum age 30/35. Preference will be given to men with mechanical and civil engineering qualifications. Previous experience on welded pipelines essential.

Required September 1960. Salary range £2160 to £2700 p.a.

PIPELINE INSPECTORS (SIX)

Required to provide general supervision over locally engaged inspectors on right-of-way clearance ditching, pipe stringing, bending, tie-ins, lower and back fill.

Preference will be given to men with previous practical pipeline experience.

Minimum age 30 years and required by 1st October 1960.

Salary range £1620 to £2160 p.a.

RESIDENT ENGINEERS— RIVER CROSSINGS (TWO)

Required to supervise inspection of Contractors' work on submerged and overhead pipeline crossings of rivers and to supervise locally engaged inspection staff. Should be qualified Civil or Structural Engineers with experience of either erection of steel structures, piling foundations, cable suspension bridges etc. or earthworks, draglines, dredging and well point dewatering.

Age 30 to 40 years. One required immediately and one 1st October.

Salary range £1800 to £2250 p.a.

CIVIL CONSTRUCTION ENGINEERS (TWO)

Required to supervise setting out and construction/erection of Domestic and Industrial buildings and services. Previous experience of contract work of a similar nature essential.

Minimum age 30 years—one required immediately and one 1st October.

Salary range £1620 to £1980 p.a.

TECHNICAL ASSISTANT (ONE)

Required immediately to assist Chief Engineer on design and technical co-ordination. Should be a qualified Mechanical Engineer with previous pipeline experience.

Minimum age 25. Salary range £1620 to £2070 p.a.

E5453 A

ROYAL VETERINARY COLLEGE. Applications are invited from married men for post of RESIDENT MAINTENANCE ENGINEER which is now available. Candidates must be ex-naval E.R.A.s or mechanicians or possess comparable experience and qualifications. Salary £675 by £25 to £725 p.a. Superannuation scheme. Summer holiday arrangements will be honoured.—Intending applicants should first send addressed envelope (for application form and further particulars) to the Secretary, Royal Veterinary College, Royal College Street, London, N.W.1. E5465 A

SENIOR MATERIAL HANDLING AND STRUCTURAL ENGINEERING DRAUGHTSMEN, age 25 to 35, required for Design and Detail Work in our Bromley, Kent, and Brighton offices. Salaries over A.E.S.D. rate, commensurate with ability and experience. 37½-hour week, 3 weeks annual holiday (one week granted this year.—Write, stating age and details of experience to John Wilson and Co. (Engrs) Ltd., 30, Widmore Road, Bromley, Kent. E2943 A

SENIOR MECH. DESIGNERS

with experience of small mechanisms required. H.N.C. preferred but not essential. Handwritten applications with full particulars and salary required to BOX No. E5374, " The Engineer."

A

SITE PLANNING AND PROGRESS ENGINEER

A National firm of chemical engineering contractors require a Site Planning and Progress Engineer. Age 25-35. Previous planning experience desirable but not essential. Duties would primarily be on site, but would involve liaison with Head Office. Pension Scheme.—Applications in writing, giving details of age, qualifications and previous experience to BOX No. E5342, " The Engineer."

A

UNILEVER LIMITED have a vacancy for a REFRIGERATION ENGINEER in their London Office. Applicants should have received fundamental training in Refrigeration and should have had substantial practical experience in this field. It is desirable that they should be knowledgeable on at least the first two of the following three subjects :

1. Refrigerated Transport Vehicles.
2. Large Industrial Refrigeration Plant.
3. Cold Store Design.

Candidates should preferably be corporate members of the Institute of Mechanical Engineers, and should have obtained a Diploma in Refrigeration Engineering. Salary will be compatible with age and experience.

Applications, in writing, giving details of training and experience, should be addressed to Head Office Staff Department (WF/62), Unilever House, Blackfriars, London, E.C.4. E5429 A

UNITED KINGDOM ATOMIC ENERGY AUTHORITY PRODUCTION GROUP

require

INSPECTION STAFF

for the Fuel Element Inspectorate, Springfields Works, Salwick, Near Preston. The Inspectorate is responsible for the design and inspection of fuel elements manufactured by the Production Group for the Civil power programme, for export reactors and for the Authority's own reactors.

FUEL ELEMENT INSPECTOR (Engineer I)

Ref. P.158/J1. To be responsible to the Assistant Chief Inspector (Fuel Elements) for the co-relation of inspection standards on all types of fuel elements throughout the Works and to maintain liaison with the Research and Development and Technical Sections. The selected candidate will be expected to exercise technical control of a large factory inspection staff which includes professional engineers in addition to industrial grades and also to maintain a high degree of efficiency of inspection at all stages in the manufacture of Fuel Elements.

SALARY : Within the range £1,880—£2,180 according to qualifications and experience.

ASSISTANT FUEL ELEMENT INSPECTOR (Engineer II)

Ref. P.159/J1. To assist the Fuel Element Inspector in the duties outlined above and, in addition, to act as liaison officer with visiting Inspectors who will be representing the customer for fuel elements. In this capacity he will be expected to provide the information assuring these Inspectors that individual types of fuel elements are being made in accordance with requirements of the specification.

SALARY : Within the range £1,370—£1,825 according to qualifications and experience.

Qualifications and Experience : Applicants must have served a recognised engineering apprenticeship and be corporate members of a Senior Engineering Institution, or hold equivalent qualifications. Experience of mechanical engineering inspection and knowledge of the techniques employed in metallurgy, X-ray and mass spectrometry is required together with the ability to utilise these services and direct them as an integral part of inspection. Candidates should also be capable of controlling and organising inspection staff of all grades.

CONTRIBUTORY SUPERANNUATION. Staff housing scheme.

Send postcard for application form, quoting appropriate reference, to Staff Officer, United Kingdom Atomic Energy Authority, Production Group Headquarters, Risley, Warrington, Lancs.

Closing date: 1st August, 1960. E5421 A

UNITED KINGDOM ATOMIC ENERGY AUTHORITY AT ORFORDNESS, SUFFOLK

require

ENGINEERS and EXPERIMENTAL OFFICERS for a team engaged on mechanical environmental testing. This team will be responsible for the planning and operation of test rigs with associated assembly, instrumentation, data interpretation and recording.

The work is interesting and often complex requiring men with a sound fundamental engineering knowledge and alert enquiring minds. The minimum qualifications required are Graduate Membership of a Professional Engineering Institution for the Engineer posts, and a pass degree or H.N.C. for the Experimental Officer posts. Previous instrumentation experience would be an advantage.

Salary : Experimental Officer : £1,045 to £1,285 p.a.
Engineer III : £860 (at age 25)—£1,175 (at age 34 or over)—£1,340 p.a.

The Authority's Establishment at Orfordness offers attractive seaside surroundings with excellent recreational facilities and a house or substantial assistance with house purchase will become available for married officers living beyond daily travelling distance. Generous leave allowance. Superannuation Scheme.

For application form please send postcard (or letter) to the Senior Recruitment Officer, A.W.R.E., Aldermaston, Berks., quoting ref. 2723./25.

E5413 A

PROFESSIONAL ENGINEER

required by

ATOMIC ENERGY RESEARCH ESTABLISHMENT, HARWELL

to be responsible

for the **design, manufacture, installation testing and commissioning of complex engineering equipment associated with RESEARCH REACTORS, to meet stringent conditions of temperature pressure and irradiation.** The work will involve :

(i) CLOSE LIAISON with SCIENTISTS to FORMULATE REQUIREMENTS
(ii) TECHNICAL CALCULATIONS
(iii) SUPERVISION OF DESIGN, MANUFACTURE and INSTALLATION of the EQUIPMENT
(iv) PREPARATION OF SPECIFICATIONS, DESIGN and OPERATING MANUALS.

STARTING SALARY within the RANGE £1370—£1825 p.a. according to qualifications and experience. Prospects of promotion to £2180 p.a.

Engineering design experience of a high technical content is desirable. Specialised instruction in nuclear science will be given.

Housing and superannuation schemes.

Please send POST CARD for details to Personnel Manager (1746/25) U.K.A.E.A., A.E.R.E., Harwell, Didcot, Berks.

E5414 A

BOOKS and PUBLICATIONS

Electronic Engineering

A monthly journal for the professional electronics engineer. It circulates to 86 different industries all over the world.

When electronic engineering is studied " Electronic Engineering " is read.

28 ESSEX STREET, STRAND, LONDON, W.C.2

Telephone: Central 6565

Published by Morgan Bros. (Publishers) Ltd.

Enter No. 1051 on reply card

Classified Advts. continued on page 106

SITUATIONS VACANT

MECHANICAL DESIGN ENGINEER

for LEEDS

Substantial engineering company with extensive overseas interests requires Mechanical Design Engineer to work in the Leeds area on earth moving and mechanical handling equipment design projects. The selected applicant must have outstanding technical ability, a mechanical engineering degree or equivalent qualification, adequate shop experience, and should preferably be between 30 and 40 years of age.

Salary will be attractive, and positive promotion to top level is intended.

Replies should be addressed to the Managing Director, and will be treated in strict confidence.

BOX No. E5419 "The Engineer" A

SITUATIONS VACANT

STRESS ENGINEER

DAVEY AND UNITED ENGINEERING COMPANY LIMITED

the largest producers and designers of rolling mill equipment in Great Britain require a Graduate Mechanical Engineer with experience of stressing techniques to expand and develop an existing stress section.

He will be responsible to the Chief Engineer for the development of standard analytical approach to general design problems, this work will entail the theoretical analysis of dynamic machines and structures subjected to impact and thermal loading. Complete research facilities exist for fundamental investigations into problems encountered, these facilities include a field research team equipped to carry out stress measurement on working components, research workshop together with a photo elastic bench. Knowledge of heavy welded fabrication techniques would be an advantage but is not essential.

Comprehensive amenities, Superannuation Scheme.

Apply with full details of age, experience and qualifications to:—

Personnel Department,
Davy and United Engineering Company Limited,
Darnall Works, Sheffield 9.

E5430 A

SITUATIONS VACANT

AN INSTRUMENTATION ENGINEER

is required by

THE STEAM TURBINE DIVISION OF ENGLISH ELECTRIC, RUGBY

Applicants should be capable of the co-ordination of specification requirements with instrument manufacturers and panel makers, and should be able to carry out liaison both with customers and consulting engineers. Previous experience of this type of work is desirable but it is essential that applicants should have at least had practical experience on test rigs.

Write, giving full details to Dept. G.P.S., Marconi House, 336-7, Strand, London, W.C.2, quoting reference E1112C.

E5420 A

SENIOR ENGINEER

A leading manufacturing Company has an interesting opening for a qualified Engineer.

Applicants should be University graduates in Chemical or Mechanical Engineering and have had some years experience in Industry.

This is an outstanding opportunity for a Senior Engineer who wishes to extend his responsibilities.

An excellent salary will be paid and the prospects of promotion are particularly good.

Please write in confidence giving full details to Personnel Manager, Box No. E 2948, "The Engineer."

A

DEVELOPMENT ENGINEER

Applications for the post of Senior Development Engineer are invited from chartered Mechanical or Civil Engineers, preferably experienced in High Vacuum metallurgy and design work. The advertising Company is engaged in developing vacuum furnace and high vacuum equipment activities, and the post will involve both the approval of specifications and estimates for equipment and the control of production for subsequent contracts. An ability to apply modern production techniques is therefore necessary. This new appointment by an expanding and progressive engineering concern, will be located in Lancashire ; it will command a good salary.

Applications must detail age, education, academic qualifications, experience, and should be addressed to :

Ref. 455,
The Wallace Attwood Company,
Chantrey House,
Eccleston Street,
London, S.W.1,

who are acting on behalf of the Company in the first instance.

E5416 A

Monsanto Regd.

MONSANTO CHEMICALS LIMITED

require

DRAUGHTSMEN

for interesting work on chemical plant design in the London Engineering Department.

Applications are invited from men aged 23–27 years, preferably having had an apprenticeship and some experience of piping and plant layout.

Good salaries, bonus and non-contributory pension scheme ; excellent working conditions.

Please send written applications, giving details of age, qualifications and experience to : DL 159, Personnel Department, Monsanto Chemicals Limited, Monsanto House, 10/18, Victoria Street, London, S.W.1.

E5444 A

THE JOSEPH RANK GROUP

BRITISH BAKERIES LIMITED

wish to appoint a young

MECHANICAL ENGINEER

to take charge of new projects as the senior member of a design team, concerned with the development of special purpose machinery and devices. The successful candidate will be required to set up a small drawing office and organise its work. He will be responsible to the Consultant Engineer, and be based in London.

Applicants should be 28/35 and either graduate or chartered engineers. Salary according to age, qualifications and experience. This is an interesting and progressive appointment.

Apply with relevant details to:— The Group Staff Manager, British Bakeries Limited, 53, Eastcheap, London, E.C.3.

E5457 A

Senior Development Engineers

A major company is seeking two experienced senior development engineers for interesting work on advanced techniques in industrial weighing.

1. University graduate, or candidate, with H.N.C. and appropriate distinctions, is required with experience in electronics, particularly in the design of circuits for servo systems and amplifiers.
2. A man with experience in investigating the problems related to electro-mechanical systems and who possesses a university degree or H.N.C. with appropriate distinctions is required. Suitable industrial experience in this field is essential.

These are both new appointments and the prospects for extended responsibility are excellent.

Write in confidence, with full details of experience and qualifications, to:—

Works Director:

W. & T. AVERY, LIMITED, BIRMINGHAM E5434 A

BCL

BRITISH CELLOPHANE LIMITED

require a

TECHNICAL SERVICE MANAGER

Applications for the position of Technical Service Manager are invited from men, aged 30/40, having the following qualifications :—

A good Science or Engineering degree.
Successful Management experience.
A balanced interest in current market problems and long term use development.
Enthusiasm, drive and ability to get on well with people.
A practical knowledge of packaging—particularly in respect of Plastic and/or Cellulose films would be an advantage.

The Technical Service Manager will be based on London, W.1., and will be responsible for departmental control of Technical Service Representatives, a Laboratory and a Machine Development Section. He will be required to establish and maintain first class relationship with the Company's customers both in the United Kingdom and overseas by personal contact where necessary. Interviews will take place in London.

Applications to Personnel Officer, British Cellophane Limited, Bridgwater, Somerset. E5370 A

SITUATIONS VACANT

George Angus and Company Limited

DESIGN DRAUGHTSMAN

Continued expansion of Company activities at our Rubber and Plastics Factory has led to our requiring the services of a draughtsman having responsible experience of production machinery design and layout, preferably obtained in the rubber industry. A wide range of industrial products is made at the Works including general and braided hose, conveyor and transmission belting.

A sound general engineering background is essential. Possession of H.N.C. in mechanical engineering is an advantage, but men with good practical experience are also invited to make application.

The vacancy is a senior one and the successful candidate will have ample opportunity to exercise initiative and ingenuity. Commencing salary is attractive and there is an annual review. Group Pension Scheme and housing assistance.

Initial interviews for selected candidates can be arranged in their home towns if requested.

Please send full details of age, education and experience to Personnel Officer, George Angus & Co. Ltd., Walker Works, St. Anthony's, Newcastle upon Tyne, 6.

E5446 A

SITUATIONS VACANT

THE STEEL COMPANY OF WALES LIMITED, TROSTRE WORKS, LLANELLY

Require

DESIGNER DRAUGHTSMEN

not under 24 years of age, preferably possessing the Higher National Certificate in Mechanical Engineering - able to work from first principles, also able to develop ideas.

Applicants must have served a bona fide apprenticeship, and preference will be given to those who have also had experience in heavy engineering.

Good working conditions including sports and canteen facilities. Free life insurance and contributory pension scheme available.

Salary range according to age, qualifications and experience.

Apply, giving full details, to:
The Supt. Labour and Wages,
The Steel Company of Wales Ltd.,
(Tinplate Division),
Carmarthen Road,
Swansea, Glam

E5445 A

SITUATIONS VACANT

WORKS, PLANT or MAINTENANCE ENGINEER

having a wide knowledge of Machine Tools and Equipment, General Factory Plant and Machinery, Boiler Plant, Service installations etc. is invited to apply for interesting specialised professional consultant work throughout the U.K. in connection with a wide range of trades.

Successful applicant will be based on, and be required to live in, London.

Age to be between 28 and 35 years.

Very good salary coupled with good prospects.

Hand write brief, but comprehensive, details to Box No. E2949 "The Engineer."

A

SITUATIONS VACANT

CIVIL ENGINEERING ASSISTANT

who has suitable qualifications and experience is required for planning and design work associated with cement works construction, salaries in accordance with ability and experience; staff profit sharing scheme and pension fund, excellent welfare and canteen facilities, very good working conditions. Interviews by appointment only.

Please apply: Chief Engineer, G. & T. EARLE LIMITED, Wilmington, Hull.

'A member of the Blue Circle Group'

E2939 A

Mullard

MULLARD SOUTHAMPTON WORKS

have a vacancy for a

GRADUATE ENGINEER

to join their rapidly expanding Plant Department. The department services an establishment concerned with research, development and quantity production of transistors, and the post calls for a man capable of progressing to a senior appointment. A post graduate apprenticeship or sound practical experience are therefore essential. The position offers an opportunity to extend practical knowledge in a very wide variety of engineering services within a large and expanding group of companies.

Please apply in writing to the Plant Personnel Officer, Mullard Southampton Works, Millbrook Industrial Estate, Southampton, quoting the reference C.14.

" Mullard " is the Trade Mark of Mullard Limited. E5458 A

DRAUGHTSMEN

Draughtsmen are required at the Midlands Research Station, Solihull.

The duties are interesting and will include work on the design of pilot and prototype plant associated with the development of new high-pressure processes for the production of town gas.

Candidates should possess at least an O.N.C. certificate in Mechanical Engineering.

The salary for the appointments, which are pensionable and subject to medical examination, will be within the range of £733–£927 per annum.

Applications, stating age, education and experience, should be addressed to the Industrial Relations Officer,

WEST MIDLANDS GAS BOARD,

6, Augustus Road, Edgbaston, Birmingham, 15.

E190 A

SITUATIONS WANTED

CHARTERED MECHANICAL ENGINEER with Degree, seeks executive position. Age 35. Works Apprenticeship. D.O. training. Experienced Design, Tendering, Sales and Works Management. —BOX No. E2944, " The Engineer." B

B.SC., A.M.I.MECH.E. Varied mechanical and ancillary struct. experience in gen. mech. and some civ. eng. plant ; planning, development and execution of novel equipment and projects ; patent work, interest commercial side.—BOX No. E2950, " The Engineer." B

MECHANICAL ENGINEER, A.M.I.Mech.E., aged 36, executive experience with large ramified organisation in plant design, manufacture and maintenance, factory layout and works engineering, seeks position of increased responsibility and remuneration with progressive industry in the South London Area.—BOX No. E2955, " The Engineer." B

FOR HIRE

LATTICE STEEL ERECTION MASTS (light and heavy), 30ft. to 150ft. high, for immediate hire.—Bellman's, 21, Hobart House Grosvenor Place, S.W.1. E103 K

BRITISH TRANSPORT DOCKS

CIVIL ENGINEERING VACANCIES

SOUTH WALES

(1)	Senior Engineering Assistants, BARRY. £1,150—£1,330 p.a. (Corporate Membership Institution of Civil Engineers)	—Experience in design, specification, construction and execution of general civil engineering works preferably with knowledge of dock and harbour installations.
(2)	Engineering Assistants, BARRY & CARDIFF. Up to £1,034 p.a. according to experience (Graduates of Institution of Civil Engineers)	—Assist in preparation of drawings, estimates and contract documents for docks civil engineering works.
(3)	Engineering Assistants, BARRY, CARDIFF & NEWPORT. Up to £948 p.a. according to experience. (Higher National Certificate)	—Experience in preparation of schemes and estimates for general civil engineering construction. Some experience on works.
(4)	Engineering Assistant, BARRY. Up to £948 p.a. according to experience. (Higher or at least Ordinary National Certificate).	—Knowledge of permanent way work with experience in surveying and design of layouts, calculation for point and crossing work, requisitioning of materials.

Contributory superannuation scheme and certain rail travel facilities.

Applications giving age, education, training, experience and qualifications not later than 3rd August to :—

Chief Docks Manager, British Transport Docks, Pierhead Building, Cardiff, Glam.

E5450 A

AUSTRALIA

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

DIVISION OF BUILDING RESEARCH

ENGINEER/MATHEMATICIAN

The Organization's Division of Building Research invites applications for a position as ENGINEER/MATHEMATICIAN from Honours graduates in Engineering or Science with mathematical ability at a high level and some years of post-graduate research experience. Through the co-operation of firms in the building industry the Division has one large experimental flat plate structure and a second is proposed. All aspects of stress distribution and deflexion of these structures are to be studied under all types of load, and eventually tested to failure. The appointee will be responsible for the theoretical behaviour of flat plates and for the analysis and interpretation of results. The Division has access to an electronic digital computer and has experienced programmers on the staff.

SALARY : Dependent on qualifications and experience within the ranges : £A1510 to £A2265 p.a. or £A2395 to £A2720 p.a.

Promotion within C.S.I.R.O. is by merit and may ultimately go beyond the upper limit of the scale within which the original appointment is made.

Fares paid. Further details of conditions, etc., supplied on application to :

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August 1	**Miscellaneous stores.**	**M.O.A. Storage Depot, Ruddington, Notts.**	**WALKER, WALTON & HANSON** (Dept. L), Byard Lane, Bridlesmith) Gate, Nottingham. (Tel.: 54272.)
August 23	**Miscellaneous stores.**	**Central Ordnance Depot, Didcot, Berks.**	**SIMMONS & SONS** (Dept. L), 12, Station Road, Reading, Berks. (Tel.: 54025.)
September 1	**Vehicles, machine tools and miscellaneous stores.**	**M.O.A. Storage Depot, Bowhouse, Hurlford, Nr. Kilmarnock, Ayrshire.**	**DIXON & WALLACE, LTD.** (Dept. L), Bank Buildings, Graham Square, Glasgow, E.1. (Tel.: Bridgeton 2447/9.)
September 6–7	**Machine tools and miscellaneous stores.**	**M.O.A. Storage Depot, Royal Arsenal, Woolwich, London, S.E.18.**	**FULLER, HORSEY, SONS & CASSELL** (Dept. L), 10, Lloyd's Avenue, London, E.C.3. (Tel.: Royal 4861.)
September 13	**Miscellaneous stores.**	**No. 1 E.S.D., Long Marston, Nr. Stratford-on-Avon, Warwicks.** (Sale at the Hippodrome, Stratford-on-Avon).	**LOCKE & ENGLAND** (Dept. L), 166, Parade, Leamington Spa, Warwicks.
September 16	**Miscellaneous stores.**	**M.O.A. Storage Depot, Rotherwas, Hereford.**	**RUSSELL, BALDWIN & BRIGHT, LTD.** (Dept. L), 20, King Street, Hereford. (Tel.: 4366.)
September 21	**Machine tools and miscellaneous stores.**	**Technical Stores Depot, Old Dalby, Leics.** (Sale at Melton Mowbray.)	**SHOULER & SON** (Dept. L), 1, Norman Street, Melton Mowbray, Leics. (Tel.: 3081.)

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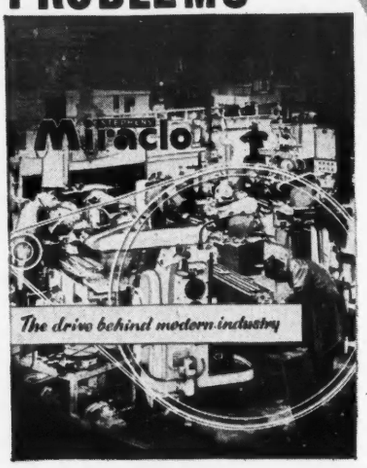

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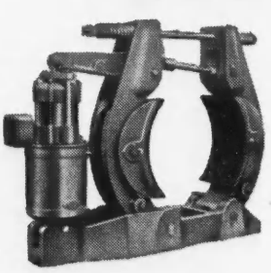

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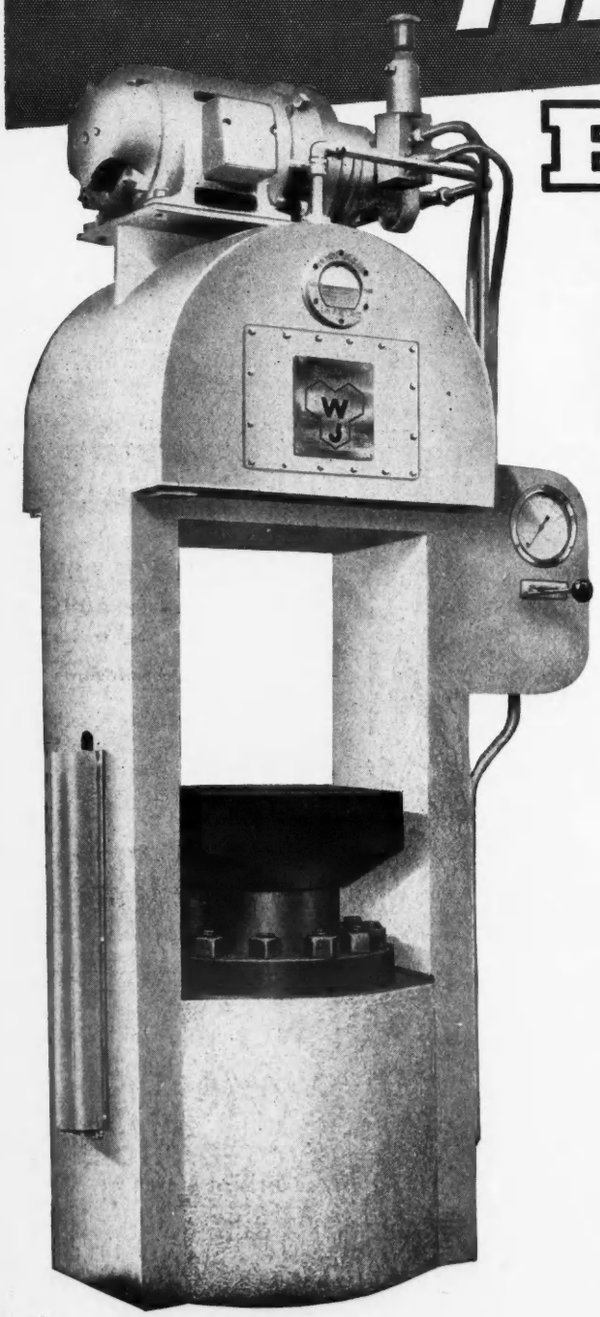

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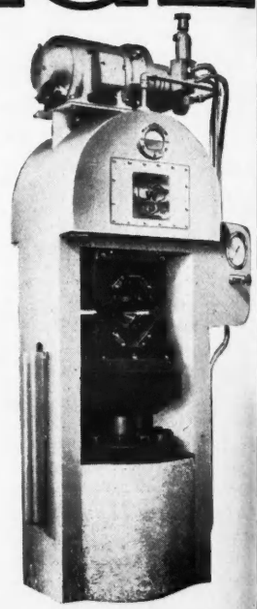

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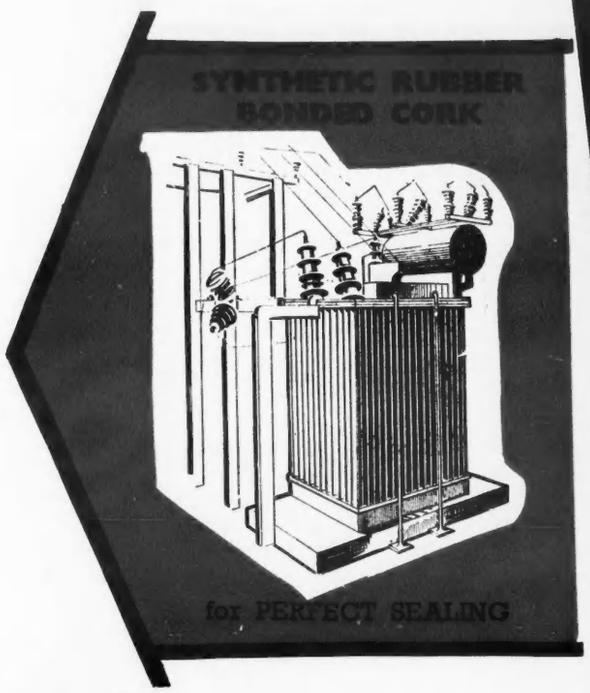

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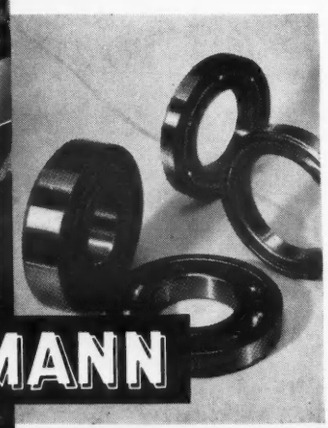

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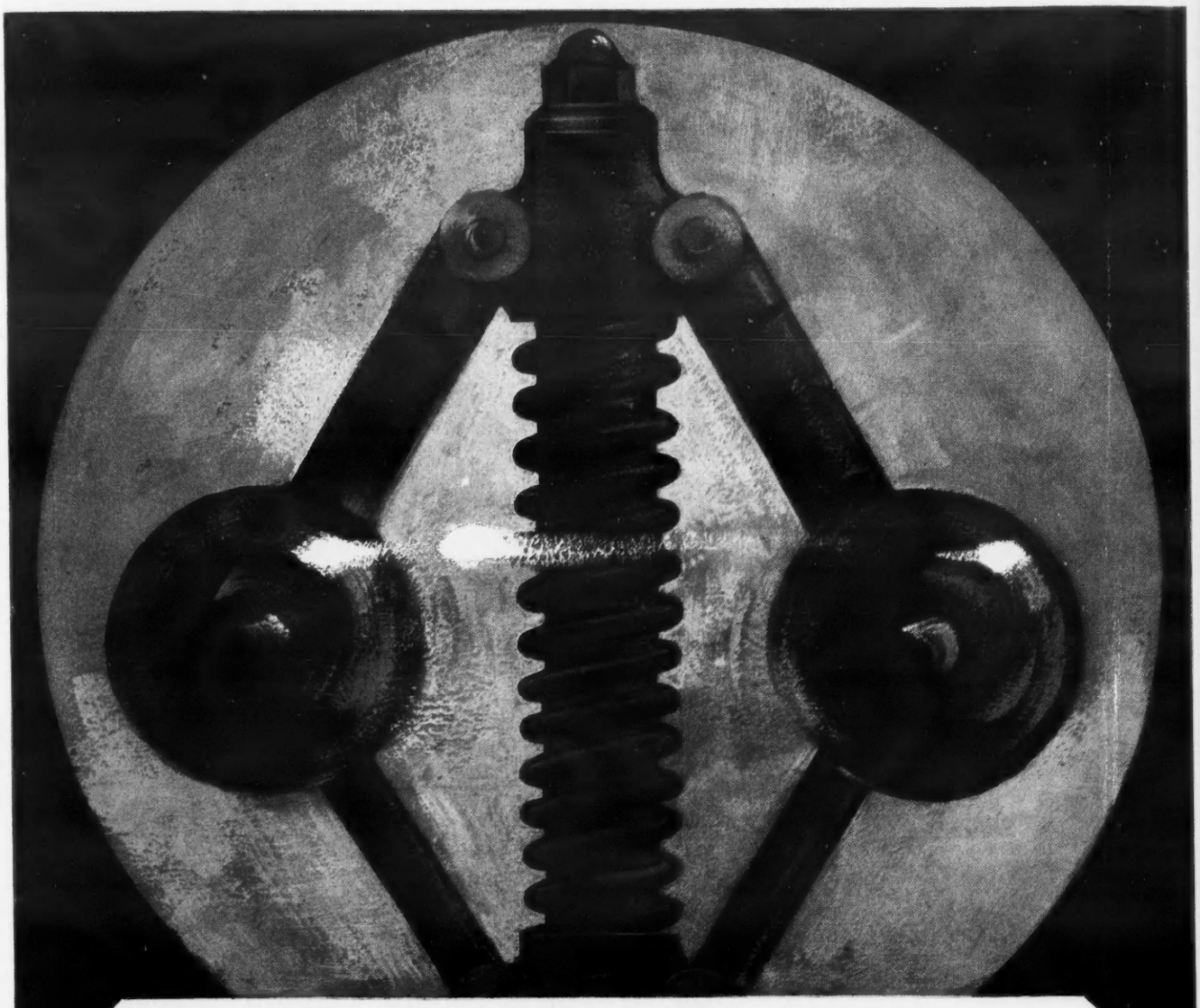

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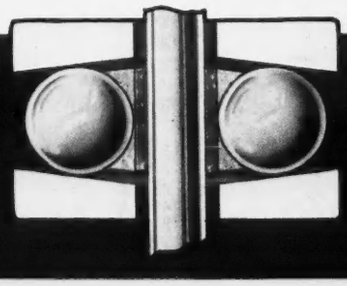

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